BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE BENCH AT CHENNAI
APPLICATION NO 14 OF 2022

IN THE MATTER OF:
M. Yuvadeeban

... Applicant

Versus

Department of Fisheries & 4 Ors.

...Respondents

INDEX

BEFORE THE NATIONAL GREEN TRIBUNAL

SOUTHERN ZONE BENCH AT CHENNAI

APPLICATION NO 14 OF 2022

M. Yuvadeeban
S/o Maragret Lawrence,
Aged about 26 Years,
B2, Ramaniyam Marvel, Seshdripuram, 1st Main Road,
Velacherry,
Chennai – 600 042. ... Applicant

-AND-

1. Department of Fisheries
Government of Tamilnadu
Rep by its Executive Engineer
Fishing Harbour Project Division
Nandanam, Chennai – 600 035
Ph: 9566254546.
tnfisheries@nic.in

2. Tamil Nadu State Environment Impact Assessment Authority
Rep by its Member Secretary,
Third Floor, PanagalMaligai,
No.1 Jeenis Road, Saidapet,
Chennai-600 015,
Tamilnadu.
Tel: 044-24359973
mstnselaa@yahoo.com

3. Principal Chief Conservator of Forests & Chief Wildlife Warden
Forest Department
Government of Tamilnadu
Tel: 044-24321738
pccf-tn@nic.in

4. Government of India
Represented by its Secretary to Government,
Ministry of Environment, Forest and Climate Change,
Paryavaran Bhavan,
Jorbagh Road,
New Delhi-110003.
Tel: 011-24695132

18.03.22
Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

5. Tamilnadu State Coastal Zone Management Authority,

Represented by the Member Secretary,
Panagal Building, Saidapet
Chennai-600 032.
Tel: 044-24336421
mstnsc2ma@yahoo.com

... Respondents

COUNTER AFFIDAVIT OF 1st RESPONDENT

I, M. Murugesan, S/o C. Muthian aged about 58 years, do hereby solemnly affirm and sincerely state as follows.

1. I am the 1st respondent herein, and discharging my duty as the Executive Engineer, 2nd Floor, Integrated Office Complex for Animal Husbandry and Fisheries Department, Nandanam, Chennai – 600 035, as such I am well acquainted with the facts and circumstances of this case from the available records. I have perused the affidavit filed by the applicant in support of documents. I deny all the averments. I am filing this application for myself and on behalf of the respondent 1.

2. It is submitted that there are 44 fishermen villages along the coastal boundary of 87.2 km in Chengalpattu District having 10 Mechanised Fishing Vessels (hereafter MFVs) and about 2200 Country crafts/Out board motorised boats (hereafter OBMs) and 19 fishermen villages along coastal boundary of 40.70 km in Villupuram District having 18 MFVs and about 1130 OBMs. As there is no fishing harbour in these districts, more than 20 MFVs are being operated from the inner sea, about 300-400m from the seashore, and the fish catches are being transported from these MFVs through OBMs to the seashore for sale. It creates lot of inconvenience to the fishermen and also spending additional manpower and fuel costs. Besides, during the cyclone and other natural calamities, these MFVs are need to be shifted to either Chennai Kasimedu Fishing Harbour or Cuddalore Fishing Harbour for safe berthing, where those fishermen are already facing congestion and other local issues; also posing step mother attitude towards the fishermen from the Chengalpattu and Villupuram Districts. Few MFVs are being operated from the Chennai Kasimedu Fishing Harbour or

1/10/3/22
Assistant Executive Engineer
Fishing Harbour Project Sub-Division

Executive Engineer
Fishing Harbour Project Division
Chennai.

Pudhucherry Fishing Harbour and those harbours are also facing traffic congestion issues.

3. It is submitted that the absence of such Fishing Harbour in Chengalpattu and Villupuram Districts, suppressed the developments in fishery activities in these areas leading to poverty and unemployment among fishermen community. They are finding much more difficulties to meet their day to day livelihood and their socio-economic status is in a very bad shape. The Government of Tamilnadu is implementing various welfare schemes to improve their living standards and developing infrastructure facilities for safe berthing of boats, easy and hygienic handling of their fish catches.

4. It is submitted that fishermen from these districts were made numerous representations to the Government for more than 25 years, for the Construction of Fishing Harbour in Kaluveli Waters, where they are operating their fishing boats since very long ago, to protect their boats during cyclones and other calamities and also to improve their socio-economic status by developing fishery activities. The Hon'ble Chief Minister of Tamilnadu made announcement that the feasibility studies will be conducted for Construction of Fishing Harbours in Kaluveli Waters at Azhagankuppam in Villupuram District and Alamparaikuppam in Chengalpattu District, during the public function of Dr. MGR Centenary Birthday Celebrations on 30-08-2017, in Kancheepuram District.

5. It is submitted that the Government of Tamilnadu has accorded administrative sanction, vide GO (D) No 113 Animal Husbandry, Dairying and Fisheries (FS-1) Department dated 06-06-2018 to carryout the techno-economic feasibility studies of the project. Accordingly, M/s Danish Hydraulic Institute (India) Water & Environment Private Limited has prepared the DPR based on the primary and secondary data of tides, winds, cyclones bathemetry, soil investigations, topographical survey and stakeholders' meeting conducted on 30-09-2019 in presence of fishermen from most of the villages. They have also conducted numerical analysis on shoreline changes due to the construction of training walls and as per the ToR,

1/03/22
Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

the oil spill management also carried out through numerical modelling analysis. ***M/s Danish Hydraulic Institute, Denmark, is a not-for-profit organisation addresses all challenges in water environments through consultancy services and their MIKE software tools for water environments are worldwide famous.***

6. It is submitted that the detailed Environmental Impact Assessment (EIA) studies were carried out by the M/s Cholamandalam MS Risk Services Limited (NABET Accredited EIA Consulting Organization – Certificate No. NABET/EIA/1922/ RA 0170), Chennai, by collecting the baseline data through field survey from 18-10-2019 to 11-11-2019 and 19-07-2020 to 09-10-2020. The impact on biodiversity in Kaluveli Waters and Sea, during pre and post construction phase have been assessed and their Environment Management as well as Monitoring Plans have been arrived to mitigate the impact and also redevelop and maintain the biodiversity have been detailed in the Comprehensive EIA Report. Due care has been taken to maintain the biodiversity of the locality.

7. It is submitted that the National Centre for Sustainable Coastal Management (hereafter NCSCM), Ministry of Environment, Forest and Climate Change, Government of India has prepared the Coastal Regulation Zone Map, in accordance with the approved CZMA of Tamilnadu, showing all the details of Coastal Regulation Zone categories and their ecologically sensitiveness, such as mangroves, sand dunes, etc. The NCSCM has reported that the site proposed for the construction of Fishing Harbour falls within the permissible activities under CRZ norms and the proposed sites are not ecologically and environmentally sensitive as per CRZ Notification 2011.

8. It is submitted that the District Level Coastal Zone Management (DCZMA) Authorities of Chengalpattu and Villupuram Districts have scrutinised our applications with Form-I and had detailed discussion on our presentation and recommended with conditions to the Tamilnadu State Coastal Zone Management Authority (hereafter TNSCZMA), vide their Lr.No.TNPCB/DEE/DCZMA/CRZ/2019 dated 27-02-2020 dated

19.03.22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

Lr.No.DEE/TNPCB/VPM/F-0067/CRZ/2020 dated 17-02-2020, respectively. The TNSCZMA has scrutinised our application with Form-I and had detailed discussion on our presentation and issued the State Level CRZ Clearance vide their proceedings No P1/525/2020 dated 15.06.2020, after careful considerations and also recommended for Environmental Clearance to TNSEIAA, ***as stipulated in 4(i)(a) and 4(i)(f) of "Regulation of permissible activities in CRZ areas" in CRZ Notification 2011 and as per Schedule 7(e) Ports, Harbours, Breakwaters, Dredging – Category B – having 12000TPA of fish handling capacity in "Categorization of Projects and Activities" of Environmental Notification 2006.***

9. It is submitted that after obtaining CRZ clearances, on-line application was submitted to Tamilnadu State Environmental Impact Assessment Authority (hereafter TNSEIAA) on 03-07-2020 vide Ltr.No.DB/D-1/C-25/2017 for Environmental Clearances (EC) and the presentation on the project was made to State Expert Appraisal Committee (hereafter SEAC) during their 172nd meeting held on 05-09-2020 and the SEAC has issued the Terms of Reference (ToR), vide their Lr. No. SEIAA-TN/F.No.7709/SEAC-C/7(e)ToR-791/2020 dated 17-10-2020 to prepare comprehensive Environmental Impact Assessment (EIA), public hearing meeting and conducting additional studies such as Turtle Nesting, Mangrove Afforestation and Kaluveli Wetlands through Academic Institutions like Annamalai University Advance Centre for Marine Biology.

10. It is submitted that the Comprehensive Environmental Impact Assessment (EIA) Report has been prepared after conducting public hearing meetings on 12-01-2021 at Marakkanam for Villupuram District under the Chairmanship of the Villupuram District Collector; and on 29-01-2021 at Thenpakkam for Chengalpattu District under the Chairmanship of the District Revenue Officer. Public from local area and four NGOs from Andhra Pradesh have attended and many of them overwhelmingly welcomed the project and expressed that the project would help to improve their livelihood and socio-economic status.

18/3/22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

Thiru.Sunanda Reddy, Environmentalist from Hyderabad, have participated, expressed his views and welcomed the project.

11. It is submitted that the on-line application was submitted to from TN-SEIAA on 30.03.2021, for environmental clearances and made presentation on 06.07.2021 before the State Expert Appraisal Committee (SEAC) during its 217th meeting and received the minutes of meeting, in which it has been directed to represent again after submitting further additional details. The same have been attended and resubmitted to SEAC during its 234th meeting on 22-09-2021. The SEAC has accepted the presentation and recommended to TNSEIAA for issue of EC. The TNSEIAA during its 476th meeting held on 27.10.2021 have accepted the recommendations of the SEAC and issued Environmental Clearance vide Lr No. SEIAA-TN/F.No. 7709/EC/7(e)/87/2021 dated 03-11-2021

12. It is to submit that the TNSEIAA has followed the due rules, regulations and procedures in issuing the EC whereas the applicant has submitted the false statements that the TNSEIAA has not applied its mind before issuing the EC. It is totally false and against the truth. The application itself is a self motivated one.

13. It is submitted that the "**Consent to Establish**" has been applied with Kancheepuram and Villupuram District Environmental Engineers, through on-line on 16-03-2022 and hard copy with fees have also been submitted on 17-03-2022 and obtained receipt for the same.

REPLY TO THE GROUNDS IN APPLICATION

A. Fisheries Department has proposed to construct the Fishing Harbours in Kaluveli Waters, which is creek and not on seafront, based on various scientific studies undertaken considering the impacts on environmental aspects, but the applicant states that the Fisheries Department is constructing the Fishing Harbours on the eroding shoreline. It shows that their inability to understand the subject. Hence, this allegation is false and baseless. ***As per the***

1/8/0222

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

report "National Assessment of Shoreline Changes along Indian Coast" published by 'National Centre for Coastal Research', Ministry of Earth Sciences, Government of India, the proposed project site is categorized a Stable coast (-0.5m/year to 0.5m/year) to low eroding coast (-0.5/year to -3.0 m/year). The below figure represents the status of the shoreline at the project site.

B. Fisheries Department has submitted the Form-I and Form-2 along with EIA Report, for getting Environmental Clearance, with relevant true information and no false or misleading information have been given. Our applications were scrutinised by the DCZMA of Chengalpattu and Villupuram Districts, TNSCZMA and TNSEIAA authorities. Hence this allegation is false and baseless.

C. Comprehensive EIA submitted by the Fisheries Department has all the information and compliances for the conditions stipulated in the ToR. Therefore the experts of the SEAC have accepted and directed to submit additional information during the 217th meeting of SEAC. Accordingly, the Fisheries Department has submitted the additional information and the same have been accepted by the SEAC in its 234th meeting. Hence this allegation is false and baseless.

D. EIA report elaborately discuss, in detail, about the biodiversity, turtle nesting, mangrove afforestation and ecology of the Kaluveli wetlands and estuary. The impact on ecology has been addressed in the EIA report in the subsection ***3.6 Ecology & biodiversity***, ***4.9 Marine Environment, 4.10 Ecological Environment, 9.8 Marine Environmental management plan, 9.10 Mangrove management plan & 9.11 Management of turtle movement.*** The applicant has not gone through the facts. Hence this allegation is false and baseless.

E. EIA report has been prepared based on the baseline data collected from 18th October 2019 to 11th November 2019 and from July 19th 2020 to October 9th 2020 which includes pre-monsoon and monsoon period. As per Indian Meteorological Department, Winter (January to February); Summer (March to June); Monsoon (July to

18/03/22
Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

August) and Post-monsoon (September to December) is followed in India. Hence this allegation is false and baseless.

F. EIA report has adequate information, data, analysis and findings, pros and cons, management plan on biodiversity, including environmental monitoring program. Hence this allegation is false and baseless.

G. EIA report has been prepared with the impact of construction of training wall and permanent opening of the estuary mouth. The opening of barmouth will help to improve the exchange of seawater with Kaluveli waters during high and low tides, which will, in-turn, helps the growth of flora and fauna and to improve marine ecology in the Kaluveli waters.

H. Public hearing notifications were made for Azhagankuppam village in Villupuram District in Dinamalar, Tamil newspaper dated 10-12-2020 and the Indian Express, English News paper dated 10-12-2020 and Alamparaikuppam village in Chengalpattu District was also published in Tamil and English daily, which are more than one month prior to the public hearing meetings conducted. The copies of the notification are enclosed. Hence, this allegation is false and baseless.

I. Public hearing proceedings were conducted in a fair and transparent manner under the chairmanship of the District Collector and all the persons were actively participated. There were representatives from the NGO on Environmental Groups from Hyderabad attended the public hearing meeting and expressed their views, conducted for Villupuram District on 12-01-2021 and 29-01-2021 for Chengalpattu. Hence, this allegation is false and baseless.

J. SEAC has discussed in detail on the EIA Report and gone through all the aspects of the impact on environment, biodiversity, ecology, turtle nesting, mangrove afforestation, wetlands etc, directed to carryout additional studies on these aspects during the 172nd

18/03/22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

meeting and again went on analysing the findings of the above studies conducted by Annamalai University, Advanced Centre for Marine Biology and directed the Fisheries Department to submit additional particulars and then considered for issue of Environmental Clearance. Hence, this allegation is false and baseless.

K. There are 44 fishermen villages in Chengalpattu District having 10 MFVs and about 2200 OBMs and 19 fishermen villages in Villupuram District having 18 MFVs and about 1130 OBMs. All the 32 MFVs are being operated from the inner sea, about 300-400m from the seashore, and the fish catches are being transported from these MFVs through OBMs to the seashore for selling. It creates lot of inconvenience to the fishermen and also spending additional manpower and fuel costs. Besides, during the cyclone and other natural calamities, these MFVs are need to be moved to either Chennai Kasimedu Fishing Harbour or Cuddalore Fishing Harbour for safe berthing, where those fishermen are already facing congestion and other local issues; also posing step mother attitude towards the fishermen from the Chengalpattu and Villupuram Districts. The fishermen from these districts are representing the Government for more than 20 years, requesting to construct the fishing harbour in this area. The applicant is not having sufficient knowledge on the need of the fishermen and fishery developments in this locality and simply expresses his views. Hence this allegations are meaningless.

L. The National Centre for Sustainable Coastal Management (hereafter NCSCM), Ministry of Environment, Forest and Climate Change, Government of India has prepared the Coastal Regulation Zone Map, in accordance with the approved CZMA of Tamilnadu, showing all the details of Coastal Regulation Zone categories and their ecologically sensitiveness. The NCSCM has reported that the site proposed for the construction of Fishing Harbour falls within the permissible area of CRZ norms and the proposed sites are not ecologically and environmentally sensitive as per CRZ Notification 2011 and Environmental Notifications 2006. Besides additional

18/3/22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

studies such as Turtle Nesting, Mangrove Afforestation and Wetlands of Kaluveli were carried out and assessed the impact of the project and also Management and Monitoring program has been evolved. There is no violation the CRZ 1(a) under the Notification 2011.

GROUNDS

Due procedures have been followed in obtaining the CRZ and EC for the Construction of Fishing Harbour in Kaluveli Waters at Azhagankuppam in Villupuram District and Alamparaikuppam in Chengalpattu District. But the Applicant, without having any knowledge on the project, lodged an appeal for creating hindrance to the work proposed for fishermen welfare.

Enlarging the Turtle Nesting Sites:

National Centre for Sustainable Coastal Management, Ministry of Environment, Forest and Climate Change, Government of India has prepared the Coastal Regulation Zone Map, in accordance with the approved CZMA of Tamilnadu, showing all the details of Coastal Regulation Zone categories and their ecologically sensitiveness, such as mangroves, sand dunes, etc. The NCSCM has reported that the site proposed for the construction of Fishing Harbour falls within the permissible activities under CRZ norms and the proposed sites are not ecologically and environmentally sensitive as per CRZ Notification 2011.***There is no sea-grass beds, mudflats, sand dunes and salt marshes in the proposed harbour sites.***

As directed by the SEAC, in its ToR, the turtle nesting near the project site has been studied by the Advanced Centre for Marine Biology, ***Annamalai University, Parangipettai, Cuddalore*** and found that the turtle nesting activities in this area is very sporadic and meager in number compared to other coasts and suggested to mount the low pressure sodium (LPS) lights for promoting turtle nesting.

The proposed site for construction of training walls at barmouth is placed where the opening of mouth takes place during monsoon period, every year. The bar mouth opening shifts on either side from year to year and also the width of mouth opening is based on the quantum of surface run-off. **The bar mouth opening takes place at any point in a stretch**

18032

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

of about 800m, ***where the turtle nesting is not at all taking place due to continuous exchange of waters during high and low tides.*** Rainfall and Surface runoff data of Kaluveli Tank, collected from Water Resources Department, to ascertain the quantum of runoff from Kaluveli Tank, which adds with the rainfall occurs on the surface of the Kaluveli backwaters, all these waters has to be discharged into sea through this bar mouth only. ***The satellite imagery of December 2021 shows the wide opening of the barmouth due to continuous rainfall. The google map showing shifting of bar mouth and various opening sizes are submitted for kind reference. The barmouth opening in December 2021 is about 540m away from the location where it opened in 2005.***

Besides, the construction of training walls will develop the considerable quantum of beach on southern part (i.e.,) in Azhagankuppam village, which will help at large to develop the turtle nesting grounds, in future. The Azhagankuppam village is located about 3 km from the proposed training walls and has been declared one of the turtle nesting and breeding sites under Tamilnadu Marine Fishing Regulation Act 1983 in Tamilnadu vide the G.O. (Ms) No 146, Animal Husbandry, Dairying and Fisheries(FS-3) Department dated 27-09-2016. Therefore, this project will surely help to turtle nesting in Azhagankuppam Village by developing beach nourishments creating more opportunities for high number of turtle nesting. Therefore, the execution of this project will certainly help to widen the turtle nesting area and more number of turtles will be hatched.

The report titled "Assessment of Coastal and Marine Ecosystem Goods and Services – Linking Coastal Zone Management to Ecosystem Services in India on Turtle Nesting Grounds" published by NCSCM in 2018-2019 does not identify the proposed area of development as a site for turtle nesting grounds.

18.03.22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

Helping the Kaluveli Bird Sanctuary:

The proposed Fishing Harbour at Azhagankuppam Village is having the least aerial distance of about 18 km from the Kazhuveli Bird Sanctuary declared by the Govt of Tamilnadu on 06.12.2021. The construction of training walls for permanent openings of barmouth will improve the exchange waters between the Bay of Bengal and Kaluveli Waters which will help to maintain the brackishness of the water in Kaluveli, suitable for growth of flora, fauna, marine species and other organisms in Kaluveli waters and in wetlands, which will, in turn, attracts the migratory birds from various parts of the World.

The Chief Secretary, Government of Tamilnadu has convened a review meeting on 15-11-2021 with Additional Chief Secretary, Animal Husbandry, Dairying and Fisheries & Fishermen Welfare Department, Principal Secretary, Environment, Forest and Climate Change, Principal Conservator of Forest, Chennai to discuss and address the impact of proposed Fishing Harbours in Kaluveli waters on the Kaluveli Bird Sanctuary.

Therefore, the construction of Fishing Harbour at Kaluveli Waters will certainly help the Bird Sanctuary by all means and will not cause any negative impacts.

Improvement of Bio-Diversity

The impact on biodiversity in Kaluveli Waters and Sea, during pre and post construction phase have been assessed and their Environment Management as well as Monitoring Plans have also been arrived to mitigate the impact and also redevelop and maintain the biodiversity have been detailed in the Comprehensive EIA Report. Due care has been taken to maintain the biodiversity of the locality.

Permanent opening of barmouth by constructing the training walls will helps to exchange the sea water with fresh water continuously, which will improve the living environment of the Kaluveli Waters and flora, fauna and other marine species will grove effectively. Proper organism growths in estuarine attracts the migratory birds and will improve the biodiversity of the Kaluveli Waters. If the bar mouth closes during ***below average rainfall year***, the salinity of the Kaluveli waters (any estuary water) increases more than 30ppt, affecting the growth of organisms, leading to degrading the ecology, which in turn will not attract the migratory birds. In this scenario,

1/4/03/22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

the biodiversity of the Kaluveli waters will be severely affected. ***If the bar mouth is permanently opened, the water will exchange between Kaluveli waters and sea continuously even during below average rainfall year, maintaining the biodiversity of the Kaluveli and its wetland regime, helping the Kaluveli Bird Sanctuary in better way.*** Therefore, opening of barmouth by construction of training walls will always helps and improves the biodiversity of Kaluveli waters and the Bird Sanctuary.

The Hindustan Times dated 29th May 2020 published news "IIT Madras dredging methodology helps Odisha's Chilika Lake to triple Irrawaddy Dolphin population" claiming that opening of barmouth helped to seven-fold increase of lake ecosystem with minimal disturbance to the environment.

Mangrove Afforestation

As per ToR, the detailed study has been conducted by the Annamalai University on the presence of mangroves in the proposed Fishing Harbour sites and identified suitable locations for mangrove afforestation. Based on the studies, ***it is proposed to carryout mangrove afforestation in about 9 Ha, as suggested by the Annamalai University, using native and non-native species, which also improves the biodiversity of the Kaluveli Waters.***

Therefore, the construction of Fishing Harbour at Kaluveli Waters will certainly helps to the Bird Sanctuary by all means and will not cause any negative impacts.

All the eminent institutions have contributed in designing of the harbour with proper shoreline management and due care has been posed in preparing the environmental impact assessment report covering the bio-diversity, turtle nesting, mangrove afforestation, Kaluveli Wetlands and Kaluveli Bird Sanctuary and minimising the impact on bio-diversity.

But the Applicant, without having any knowledge of the project, appealed in the Hon'ble National Green Tribunal for creating hindrance to the work proposed for the benefits of fishermen community.

1/03/22
Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

In the light of above facts and circumstances, it is most respectfully prayed that this Honourable Tribunal may please to

1. Dismiss this application under grounds that the facts stated by the applicant is totally false, against truth, baseless and motivated.
2. May be allowed to continue the work, as the fisheries department has followed all the procedures and norms in obtaining CRZ and environmental clearances.
3. Being the public welfare scheme and Government project, delay in execution affects the general public in getting their basic rights in time and also escalation in project cost, which is again the public money will be spent for creating this Fishing Harbour.

solemnly affirmed at Chennai on this day of March2022 and signed in my presence.

Before me

Advocate: Chennai

18.3.22

Assistant Executive Engineer
Fishing Harbour Project Sub-Division
Cuddalore.

Executive Engineer
Fishing Harbour Project Division
Chennai.

ANNEXURE-1

Tamil Nadu State Pollution Control Board

Online Consent Management & Monitoring System

Ministry of Environment, Forest and Climate Change
Government of India

Home | Consent Management | Laboratory Management | Waste Management | CESS Management | Knowledge Base | Logout

- Industry Profile
- Apply For Consent
- Change Password
- Delete Application
- Consent Fee Calculator
- Online Payment Verification
- View Notices

Send us your feedback and suggestions

click here for any kind complaints or query

Welcome FISHING HARBOUR AT AZHAGANKUPPAM IN VILLUPURAM DISTRICT — Date : 16-3-2022

Consent Application Details

Application No : 44139829

Congratulations! Application submitted successfully.
Please submit the signed hard copy of application with required signed enclosures to concerned District office on request of DEE/AEE concerned.

Your Consent Application application has been received under the Application Number **44139829**. *(Note this number for future communication and know the online status of the application submitted)*

Submitted application is under processing. Please send the following documents by post/by hand. You may ignore sending the documents which have been uploaded online.

1) A covering requisition letter stating the status of the industry and activities clearly.

2) Copy of attested sale Deed /Lease Deed or any other relevant documents as proof to ensure possession of the site/factory for which application is made by the applicant.

3) Copy of attested Memorandum of Articles in case of Public/Private sectors or registered partnership deed in case of partnership company.

4) Layout plan showing the location of various process equipments, utilities like boiler, generator etc, effluent treatment plant, outlet location, non-hazardous and hazardous waste storage yard.

5) Topo sketch showing the distance of water bodies, roads, existing/proposed residential areas, agricultural lands, important religious locations, educational institutions, ancient monuments, archeological places and other sensitive areas for 1 KM. radius from the units.

6) Detailed manufacturing process for each product along with detailed process flow chart.

7) Details of Water Balance and wastewater balance for process.

8) Details of Material balance for each products and process.

9) Land use classification certificate as obtained from CMDA/ DTCP/LPA.

10) Auditor Certificate with break up details for the proposed Gross fixed Assets duly certified by a Chartered Accountant in the prescribed format.

11) Consent fee under Water and Air Acts payable to the Board.

12) Ground water clearance obtained from the competent Authority(If applicable).

13) Sewage Treatment Plant(STP) proposal which must contain details of design characteristics of sewage, treatment methodology, mode of disposal, design criteria for various units, detailed drawing of STP and its layout, diagram showing the hydraulic profile and mode of disposal of treated sewage and its adequacy(If applicable).

14) Effluent Treatment Plant (ETP) proposal which must contain details including breakup quantity of water requirement with sources, breakup quantity of trade effluent, sources of trade effluent, characteristics of wastewater, treatment methodology, mode of disposal, design criteria for various units, detailed drawing of ETP and its layout, diagram showing the hydraulic profile and mode of disposal of treated effluent and its adequacy (If applicable).

15) Air pollution control (APC) measures proposal which must contain the details regarding fuels used, sources of emission, characteristics, concentration and quality of pollutant, proposal along with design criteria and drawing for the proposed APC measures, adequacy of APC measures and stack, odour/noise causing operations and its specific odour/noise control measures(If applicable).

16) In case of hazardous chemicals used as raw materials, the Material Safety Data Sheets (MSDS) should be enclosed for each and every item. If the quantity of the hazardous chemicals handled is more than the threshold limit, the unit shall furnish any one or combination of the following documents as required under the MSIHC Rules (If applicable).: Risk assessment report/Onsite emergency preparedness plan/Off site emergency preperedness plan.

17) In case of transport of hazardous chemicals, details of chemicals transported, method of transport and its safety measures (If applicable).

18) Industries attracting EIA Notification shall submit Environmental Clearance obtained from the MOEF/SEIAA along with the Environmental Impact Assessment Report (If applicable).

19) CRZ clearance obtained from the competent Authority (If applicable).

To view the submitted application form click onto "View Application Form" and To print the application form click onto "Print Air Application Form" and "Print Water Application Form"

View Application Form

Print Air Application Form
Print Water Application Form

In case documents have not been submitted online, kindly send the above documents at the earliest to start application processing on the below address or at corresponding regional office:

Head Office Address
Member Secretary
Tamil Nadu Pollution Control Board
76, Mount Salai,Guindy,Chennai - 600 032,
Channai, India
Phone: +91-44 - 22353134,22353141
Website: http://www.tnpcb.gov.in
District Office Address

ANNEXURE-1

3/16/22, 5:59 PM SPCB Admin Home

Tamil Nadu State Pollution Control Board

Online Consent Management & Monitoring System

Ministry of Environment, Forest and Climate Change
Government of India

Home | Consent Management | Laboratory Management | Waste Management | CE 35 Management | Knowledge Base | Logout

- Industry Profile
- Apply For Consent
- Change Password
- Delete Application
- Consent Fee Calculator
- Online Payment Verification
- View Notices

Send us your feedback and suggestions

click here for any kind complaints or query

Welcome: ALAMPARAIKUPPAM FISHING HARBOUR Date 16-3-2022

Consent Application Details

Application No : 44139020

Congratulations! Application submitted successfully.
Please submit the signed hard copy of application with required signed enclosures to concerned District office on request of DEE/AEE concerned.

Your Consent Application application has been received under the Application Number **44139020**. *(Note this number for future communication and know the online status of the application submitted)*

Submitted application is under processing. Please send the following documents by post/by hand. You may ignore sending the documents which have been uploaded online.

1) A covering requisition letter stating the status of the industry and activities clearly.

2) Copy of attested sale Deed /Lease Deed or any other relevant documents as proof to ensure possession of the site/factory for which application is made by the applicant.

3) Copy of attested Memorandum of Articles in case of Public/Private sectors or registered partnership deed in case of partnership company.

4) Layout plan showing the location of various process equipments, utilities like boiler, generator etc, effluent treatment plant, outlet location, non-hazardous and hazardous waste storage yard.

5) Topo sketch showing the distance of water bodies, roads, existing/proposed residential areas, agricultural lands, important religious locations, educational institutions, ancient monuments, archeological places and other sensitive areas for 1 KM. radius from the units.

6) Detailed manufacturing process for each product along with detailed process flow chart.

7) Details of Water Balance and wastewater balance for process.

8) Details of Material balance for each products and process.

9) Land use classification certificate as obtained from CMDA/ DTCP/LPA.

10) Auditor Certificate with break up details for the proposed Gross fixed Assets duly certified by a Chartered Accountant in the prescribed format.

11) Consent fee under Water and Air Acts payable to the Board.

12) Ground water clearance obtained from the competent Authority(If applicable).

13) Sewage Treatment Plant(STP) proposal which must contain details of design characteristics of sewage, treatment methodology, mode of disposal, design criteria for various units, detailed drawing of STP and its layout, diagram showing the hydraulic profile and mode of disposal of treated sewage and its adequacy(If applicable).

14) Effluent Treatment Plant (ETP) proposal which must contain details including breakup quantity of water requirement with sources, breakup quantity of trade effluent, sources of trade effluent, characteristics of wastewater, treatment methodology, mode of disposal, design criteria for various units, detailed drawing of ETP and its layout, diagram showing the hydraulic profile and mode of disposal of treated effluent and its adequacy (If applicable).

15) Air pollution control (APC) measures proposal which must contain the details regarding fuels used, sources of emission, characteristics, concentration and quality of pollutant, proposal along with design criteria and drawing for the proposed APC measures, adequacy of APC measures and stack, odour/noise causing operations and its specific odour/noise control measures(If applicable).

16) In case of hazardous chemicals used as raw materials, the Material Safety Data Sheets (MSDS) should be enclosed for each and every item. If the quantity of the hazardous chemicals handled is more than the threshold limit, the unit shall furnish any one or combination of the following documents as required under the MSIHC Rules (If applicable).: Risk assessment report/Onsite emergency preparedness plan/Off site emergency preparedness plan.

17) In case of transport of hazardous chemicals, details of chemicals transported, method of transport and its safety measures (If applicable).

18) Industries attracting EIA Notification shall submit Environmental Clearance obtained from the MOEF/SEIAA along with the Environmental Impact Assessment Report (If applicable).

19) CRZ clearance obtained from the competent Authority (If applicable).

To view the submitted application form click onto "View Application Form" and To print the application form click onto "Print Air Application Form" and "Print Water Application Form"

View Application Form | Print Air Application Form
Print Water Application Form

In case documents have not been submitted online, kindly send the above documents at the earliest to start application processing on the below address or at corresponding regional office:

Head Office Address
Member Secretary
Tamil Nadu Pollution Control Board
76, Mount Salai,Guindy,Chennai - 600 032,
Channai, India
Phone: +91-44 - 22353134,22353141
Website: http://www.tnpcb.gov.in
District Office Address

https://ocmms.tn.gov.in/OCMMS/indApplicationDetails/paymentOption 1/2

ANNEXURE-2

சிங்காரவேலர் புகழ் வாழ்க!

ஆலம்பறை கடப்பாக்கம்
ஒருங்கிணைந்த மீனவர்
பஞ்சாயத்து சபை

கடப்பாக்கம் அஞ்சல்,
செய்யூர் வட்டம், காஞ்சிபுரம் மாவட்டம் Pin-603 304.

பஞ்சாயத்து சபை நிர்வாகிகள், ஆலம்பறை கடப்பாக்கம்

ம. மாயகிருஷ்ணன்
செல் : 8489840765

வெ. முத்துவேல்
செல் : 9626330374

கோ. சுந்தரம்
செல் : 9943907177

ஆ. செல்வராஜ்
செல் : 9786058280

ஹ. துளசிராமன்
செல் : 9787892102

க. அன்னப்பன்
செல் : 9786058470

க. ராமகிருஷ்ணன்
செல் : 9585979334

செ. மதிவாணன்
செல் : 9943539665

ரெ. ரஞ்சித்குமார்
செல் : [illegible]

தேதி.........................

பெறுநர்: திரு உதவி இயக்குனர் மீன் வளத்துறை அவர்கள்,
தமிழ்நாடு அரசு,

பொருள்: எங்கள் ஊரில் உள்ள முகத்துவாரம் அடையாமல் இருக்க வேண்டும் என்பதை குறித்து.

ஐயா வணக்கம்,

எங்கள் மூன்று மீனவ கிராமங்களிலும் 13 விசை படகுகளும், 300-க்கும் மேற்பட்ட FRP பைபர் படகுகளும் உள்ளன. எங்கள் கிராமத்தில் உள்ள விசைப்படகுகள் வல்லம் ஆகியவற்றை புயல், காற்று, வெள்ளம் ஆகிய பேரிடர் நேரங்களில் எங்கள் கிராமத்தில் இருந்து சுமார் 100 கிலோ மீட்டர் தூரம் உள்ள சென்னை மற்றும் கடலூர் ஆகிய மீன்பிடி துறைமுகத்துதிற்கு கொண்டு செல்லும் போது புயல் காற்றில் சிக்கி பல நேரங்களில் படகு சேதம் ஏறபடுவதோடு, எங்களை காப்பாற்றி கொள்வதற்கும் மிகவும் சிரமப்படுகிறோம். மேலும் பயண நேரமும், செலவும் அதிகமாகிறது. எனவே மாண்மிகு அமைச்சர் அவர்கள் மற்றும் மீன் வளத்துறை இயக்குநர் இணை இயக்குநர், உதவி இயக்குநர் அவர்கள் எங்களின் நிலையை கருத்தில் கொண்டு எங்கள் கிராமத்தில் உள்ள முகத்துவாரம் அடையாமல் இருப்பதற்கு எங்கள் ஊர் முகத்துவாரத்தை ஆழம் அகலப்படுத்தி வாயின் பகுதியில் இரண்டு பக்கமும் கற்களை கொட்டி எந்த நிலையிலும் முகத்துவாரம் அடையாமல் இருப்பதற்கும், எந்த நேரங்களிலும் மேற்படி மீன்பிடி விசைப்படகுகளிலும் FRP பைபர் போட்டுகளும் மீன்பிடிக்க சென்று வருமாறு அமைத்து தரும்படி மிகவும் தாழ்மையோடு கேட்டு கொள்வதுடன், இவற்றால் விழுப்புரம் மாவட்டம், கடலூர் மாவட்டம், மீனவர்களும் பயன் அடைவார்கள் என்பதை தாழ்மையுடன் தங்கள் கவனத்திற்கு கொண்டு வருகிறோம். எங்களின் வாழ்வாதாரம் சிறப்பாக அமைய வழிவகை செய்ய வேணடும் என தங்களை பணிவுடன் கேட்டுக்கொள்கிறோம்.

இங்ஙனம்,
மேற்படி மீனவ கிராம நிர்வாகிகள்.

H. துளசிராமன்
A. பன்னீர்செல்வம்
மாயகிருஷ்ணன்
S. Ranjithkumar
செ. மதிவாணன்

232

தேதி: 31/01/2017

அனுப்புநர்:

கிராம பஞ்சாயத்தார்கள்,
ஆலம்பரைக்குப்பம் தண்டுமாரியம்மன் பகுதி,
ஆலம்பரைக்குப்பம் ஊத்துக்காட்டம்மன் பகுதி,
கடப்பாக்கம் குப்பம்,
கடப்பாக்கம் அஞ்சல், செய்யூர் வட்டம்,
காஞ்சிபுரம் மாவட்டம் - 603304.

பெறுநர்:

உயர் திரு. உதவி இயக்குநர் அவர்கள்
மீன் வளத் துறை
காஞ்சிபுரம் - மண்டலம்
நீலாங்கரை - சென்னை

பொருள் : தூண்டில் வளைவு அமைத்து தர வேண்டுதல் குறித்து:

ஐயா வணக்கம்,

எங்கள் மூன்று மீனவ கிராமங்களில் 13 விசை படகுகளும், 300–க்கும் மேற்பட்ட FRP பைபர் படகுகள் உள்ளன. எங்கள் கிராமத்தில் உள்ள விசைப்படகுகள் வல்லம் ஆகியவற்றை புயல், காற்று, வெள்ளம் ஆகிய நேரங்களில் எங்கள் கிராமத்தில் இருந்து சுமார் 100 கிலோ மீடடர் தூரம் உள்ள சென்னை மற்றும் கடலூர் ஆகிய மீன்பிடி துறைமுகத்திற்கு கொண்டு செல்லும் போது புயல் காற்றில் சிக்கி பல நேரங்களில் படகு சேதம் ஏற்படுவதோடு எங்களை காப்பாற்றி கொள்வதற்கும் மிகவும் சிரமப்படுகிறோம். மேலும் பயண நேரமும், செலவும் அதிகமாகிறது, எனவே அய்யா அவர்கள் எங்களின் நிலையை கருத்தில் கொண்டு எங்கள் கிராமத்தில் தூண்டில் வளைவு அமைத்து தந்து எங்களின் வாழ்வாதாரம் சிறப்பாக அமைய வழிவகை செய்ய வேண்டுமென தங்களை பணிவுடன் கேட்டுக்கொள்கிறோம்.

இங்ஙனம்,

V. Muthu
A.R. [illegible]
A. Raja

[illegible signatures]

ANNEXURE-3

Stakeholders’ Meeting Conducted 0n 30-09-2019

ANNEXURE-4

TAMILNADU POLLUTION CONTROL BOARD

PUBLIC NOTICE

Whereas, as per Environmental Impact Assessment Notification, 2006 as amended, Public Hearing has been made as mandatory for certain projects covered in Schedule of the said Notification.

Whereas, Public Hearing has to be conducted by State Pollution Control Board as per paras (2) and (3) of Appendix – IV of Environmental Impact Assessment Notification, 2006 as amended.

Whereas, as required under paras (2) and (3) of Appendix – IV of Environmental Impact Assessment Notification, 2006 as amended, public hearing is to be conducted by the Tamilnadu Pollution Control Board for the following project as below.

Name & Location of the Project	Date & Time	Place of Public Hearing
Proposed Construction of Fishing Harbour by Fisheries Department, Government of Tamilnadu in Kazhuveli Waters in an extent of 3.42 Hectares at S.F. No. 49/2 of Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District for handling annual fish catch of 12000 Tonnes.	29.01.2021 & 10.30 A.M.	Sri Sairam Mahal, Door.No.19/6, Thenpakkam, ECR, Kolathur P.O, Cheyyur Taluk, Chengalpattu District – 603 304.

In this connection, it is informed that the Executive Summary of EIA in English & Tamil, draft EIA report in soft and hard copies of the above said project is made available for reference to the public in the following places.

1. The Secretary to Government, Environment & Forest Department, St. George Fort, Secretariat, Chennai – 600 009. 2. The District Collector, Chengalpattu District, Chengalpattu – 603 001. 3. District Industries Centre, Kancheepuram – 631 501. 4. The Executive Officer, Edaikazhinadu Town Panchayat, Kadapakkam & Post, Cheyyur Taluk, Chengalpattu District – 603304. 5. The Block Development Officer, Chithamur Panchayat Union, Chithamur, SH-115, Cheyyur Vennangupattu Road, Chengalpattu District – 603313. 6. The Librarian, Government Branch Library, 5/55, Salt Road, Cheyyur, Chengalpattu District – 603 202. 7. The District Environmental Engineer, Tamil Nadu Pollution Control Board, Maraimalai Adigalar Street, Maraimalai Nagar, Chengalpattu District- 603209. 8. The Member Secretary, Tamil Nadu Pollution Control Board, 76, Mount Salai, Guindy, Chennai – 600 032. 9. The Ministry of Environment, Forest and Climate Change, Regional Office (SEZ), 1st & 2nd Floor, Handloom Export Promotion Council, No. 34, Cathedral Garden Road, Nungambakkam, Chennai -600 034. 10. The State Level Environment Impact Assessment Authority-Tamil Nadu, 3rd Floor, Panagal Maaligai, No.1 Jeenis Road, Saidapet, Chennai-600 015.

Suggestions, views, comments and objections from the public are invited within 30 days from the date of publication of this notice by the District Environmental Engineer, Tamil Nadu Pollution Control Board, Maraimalai Nagar.

All persons including bonafide resident, Environmental Groups and others located in the project site / sites of displacement / sites likely to be affected can participate in the Public Hearing and they can also make Oral / Written suggestions to the District Environmental Engineer, Tamil Nadu Pollution Control Board, Maraimalai Nagar on the above subject.

Member Secretary,
Tamilnadu Pollution Control Board,
Chennai - 32.

DIPR/1284/DISPLAY/2020

` **ANNEXURE-5**

PROCEEDINGS OF THE PUBLIC HEARING CONDUCTED FOR THE PROPOSED CONSTRUCTION OF FISHING HARBOUR BY TAMIL NADU FISHERIES DEPARTMENT, GOVERNMENT OF TAMILNADU IN KAZHUVELI WATERS AT S.F.NO.49/2 IN AN EXTENT OF 3.42.00 HECTARES AT ALAMPARAIKUPPAM VILLAGE, CHEYYUR TALUK, CHENGALPATTU DISTRICT.

Date: 29.01.2021 Time: 10.30 A.M

Venue: Sri Sairam Mahal, Door No.19/6, Thenpakkam, ECR, Kolathur Post, Cheyyur Taluk, Chengalpattu District.

Presided by:

1. **Thiru. A.Rajagopalan** : **District Revenue Officer,**(FAC) **Chengalpattu District.**

2. **Thiru.D.Vasudevan** : **District Environmental Engineer, Tamil Nadu Pollution Control Board, Maraimalai Nagar.**

The Project Proponent and the Public (157 Nos.) attended the Public Hearing (List enclosed).

Public hearing was conducted on 29.01.2021, 10.30.A.M at Sri Sairam Mahal, Door No.19/6, Thenpakkam, ECR, Kolathur Post, Cheyyur Taluk, Chengalpattu District on the proposed construction of Fishing Harbour by Tamil Nadu Fisheries Department, Government of Tamilnadu in Kazhuveli waters at S.F.No.49/2 in an extent of 3.42.00 Hectares in Alamparaikuppam Village, Cheyyur Taluk, Chengalpattu District.

At the outset, the District Environmental Engineer, Tamilnadu Pollution Control Board, Maraimalai Nagar welcomed the District Revenue Officer, Government officials, Environmentalists and the public present in the public hearing meeting conducted on behalf of Tamilnadu Pollution Control Board. He informed that the detailed study report on Environment Impact Assesment relating to the construction of the proposed fishing harbour project will be presented by the EIA Consultant on behalf of Tamilnadu Fisheries Department to the public.He requested the public to offer their views, opinions and suggestions about the proposed project after mentioning their name and address. He requested the project proponent and their EIA Consultant to present their proposed project details to the public in detail.

Mr. Dinesh Kumar, Manager, DHI (India) Water and Environment Private Limited, New Delhi, the consultant of the project has welcomed all the gatherings and briefed about the proposed project with the help of power point presentation.

After the technical presentation of the consultant, the District Environmental Engineer, Tamilnadu Pollution Control Board, Maraimalai Nagar has requested the public present in the meeting to air their views on the proposed fishing harbour project after mentioning their name and address.

Accordingly, the public attended the meeting raised their comments and suggestions as detailed below.

1. **Thiru. Ravi, Ex-President, Kolathur:**
   He welcomed the proposed project but suggested that it would be helpful if the proposed harbour is setup in sea front instead of Kaluveli waters as in Kasimedu fishing harbour. He raised concern that ihe proposed project will affect the livelihood of nearby village community who catch fish with bare hands and also will affect the salt pan of Marakanam, Villupuram District which is the third largest salt pan in Tamilnadu.He explained that during new moon day and fullmoon day the water level will raise and enter kaluveli waters reaching agricultural lands of villages. He cited an example that during festival days due to large people gathering large quantity of wastes are dumped and it will take 3 to 4 days to clean. Similiarly, in kaluveli waters if 1000 nos of boats are engaged, then the diesel oil used by the boats will spill and affect the salt pans, agricultural lands and the livelihood of village community who catch fish using bare hands.We are not opposing the project, but suggested that the proposed harbour shall be established in the sea front like in Kasimedu.

2. **Thiru Kannan Chandran, Advocate, Thenpakkam:**
   He thanked the Government officials and the public and stated that this fishing harbour project was earlier proposed to be setup in the sea waters between Cuddalore to Kasimedu as per the Government announcement in assembly in the year 2019 and has sanctioned fund as earlier stated during the presentation

by the proponent.Eventhough the public welcomed the project, some people still feel that the details presented in the meeting are not sufficient and requested to brief in detail about the environmental impact and the employment opportunities due to this project. He requested the officials to offer solutions to those people who catch fish using barehands who are likely to get affected. They say that the ground water won't get affected but here in kolathur, due to operation of private hatchery the ground water gets affected and even after the protest made by the people, the hatchery is in still operation. He welcomed the project if adequate measures are taken up to control the environmental impacts and problems due to increase in the traffic are addressed properly.

As Thiru.Ravi tried to speak again some people opposed stating that all must be given opportunity to speak. The District Environmental Engineer assured that all will be given opportunity to voice their opinion and those who allready spoken if they want to speak can air their views again at the end of the meeting. Assistant Director, Department of Fisheries also insisted the same to the public.

3. **Thiru. Eshwaramoorthy, Thandumariamman area, Alamparaikuppam:**
   He welcomed the fishing harbour project as all the fishermen in the districts of Kancheepuram and Villupuram are struggling for the past 40-45 years without a harbour.He asked the people to support the project as it will not only benefit the fishermen but all the people in the surrounding area.

4. **Tmt. Komala, Dalit Women Development Association:**
   She welcomed the project but expressed her concern regarding the Government's choice of establishment of the harbour in kaluveli back water instead of sea water, as it will affect the livelihood of the villages along the back waters especially dalit women who catch fish, prawn and crab by bare hands in the back waters. Due to the proposed project the water quality will be affected by the wastes and oil spillage from boats. She has also made written submission in this regard.

5. **Thiru. Saralan.B.Com, Muttukadu Village:**
   He voiced his concern for the proposed project in Buckingham canal back waters (Kaluveli waters) as it will affect the livelihood of adidravidar people in the

surrounding villages and the proposed project will be welcomed by the public if the project is established in the sea front.

6. **Thiru. Narayanan, Kadalurkuppam:**

He welcomed all the Government officials and the public who attended the meeting. He welcomed the project and stated that only kancheepuram district doesn't have fishing harbour and they have been fighting for this harbour for the past 40 years. He stated previously along with the Chief Engineer, Department of Fisheries had identified 3 locations for establishing the fishing harbour in an estimate of Rs. 108 Crores however the project has not been taken up due to various reasons. He also has stated except in Kasimedu all the existing fishing harbours have been established in the confluence point of back waters and sea waters as seen in Pondichery, Chidambaram, Poompuhar and Nagaipattinam and there are no problems till now. There also dalits live and they are not affected. Only we fishermen are affected. Government is providing this fishing harbour only to safeguard our livelihood. In case of any natural disaster a fisherman can get starngled in deep sea water, he will not survive because of high tides but if he reaches through harbour his life can be saved.

He also mentioned that if fishing harbour comes not only the fishermen community to be benefitted but will also provide employment opportunity to a lot of people other than fishermen as the people who transports fish from the harbour and the loading and unloading men are all not fishermen. He further asked the officials to take adequate steps to reduce the erosion effects due to this proposed project as it was evident from the fact that because of Kasimedu harbour the nearby villages were affected.

7. **Thiru. Ranjith, Kadalurkuppam:**

He welcomed all the gatherings and stated that the economic growth of a country depends on the growth of Harbours. Harbours are not only for fishermen but for the whole community around the harbour. Because of Harbour the roads and transport facilities will develop and employment opportunities will increase. Once this project is commenced then within 10 years, the land value will increase. Because of this project, small fisherman of this district will develop by carrying out fishing activity using steamer boats same like Chennai and

15

Nagapattinam fishermen. He once again welcomed the project as it will not only help one community but will benefit everyone around it.

8. **Thiru.Dinakaran, Panaiyur Periyakuppam:**

He stated that the people of 4, 5 villages are fighting for this project for more than 40 years. Since there is no harbour around this area they have to spend around Rs.130 for tractors to take their boats from land to the sea and like that around 500 boats are using tractors. So all those money spent for tractors will become earning once this project is commenced. One basket of fish is sold for Rs. 500 in Alamparikuppam village whereas in Panniyur Periyakuppam village one basket of fish is sold for Rs. 150 only and this will change once the harbour comes. All the fishermen will get the same value for their fishes. Surely, if this project comes nearby villages will get affected.Whereas when Keerapalaiyam harbour in Pondiherry was established the villages like chandrakuppam, chinnamaduvanchavadi and naduvankuppam were protected by providing groynes , likewise 3 villages near to Alamparaikuppam should be protected and shoud not get affected because of this project. So please make necessary steps to protect them and then start the implementation of the harbour project. Further, if the harbour comes the life of the boat will increase by 3 years rather than 3 months as of now hence we must welcome this harbour project.

9. **Thiru. Chokkalingam, AlamparaiKuppam:**

He welcomed the implementation of the fishing harbour project in Kaluveli waters as it will help the livelihood.He aslo stated that the salt pans near Cuddaloor fishing harbour has not been affected and therefore there wont be any damange to the salt pans operating in this area due to the implementation of this fishing harbour.

10. **Tmt. Amul, Muttukadu:**

She expressed her concern as it will affect the village people who collect mussels and do business which will get affected. Mostly women who do this work will greatly get affected because of this harbour project. Because of boats and large lorries the area will get crowded and it will affect their livelihood.

11. Thiru. M. Marimuthu, Periyakuppam:

He expressed his gratitude and said that all the people felt happy for the implementation of this project as it will give employment opportunity. He requested the officials to build protection wall as during heavy cyclone because of this river mouth, sea water enters the village easily and people are getting affected. We have opposed the coal handling project as the conveyor system has been proposed accordingly crossing our village as it will affect the village whereas because of this project people will be benefited and so we must welcome this project.

12. Thiru. Muthuvel, AlamparaiKuppam:

He welcomed all the officials on behalf of Chengalpattu fishermen and stated that all the people including adhi dravidar community living in our villages will be benefitted as they also do fishing using boats. He also stated that they have been struggling for the past 40 years to get this project as there is no harbour in Villupuram and Chengalpattu District. People live near the bridge about 1km far from the proposed harbour were only fishing using barehands and they will not be affected because of this project. He thanked the officials on behalf of villagers for bringing this harbour.

13. Thiru. Mani, Panaiyur Periyakuppam:

He welcomed all the gatherings and stated that it is a dream project for all the fisherman community and expressed his gratitude to the Government. He also requested to implement the fishing harbour project immediately so as to enhance their livelihood as it will improve the roads in this area and people will come forward to buy lands which will fetch more income. It will give employment opportunity to the educated. He once again thanked the Tamil Nadu Government, Ministers, District Collector and officials for implementing this project.

14. Thiru. Rajesh, Kolathur:

He welcomed the project but voiced his concern regarding the damages it will bring to the villages and stated that he had gone through websites and youtube and learned through friends that because of thoothukudi harbour more damage has been done rather than the benefits. Sea water enters and goes through river

17

mouth of Kaluveli waters and it will not be constant all the time. Due to large boats entering the water it will get polluted and village women who catch fish by bare hands will be affected and lose their livelihood. Harbour will bring development but it must not affect the poor people. If any oil spillage from the boats, it will pollute the water and these women in village cannot have their livelihood. I welcome the effort made for 40 years to bring this project but must also consider the livelihood of 300 to 400 people who do bare hand fishing as their livelihood. He stated that the views aired by him are on behalf of the villagers to whom he consulted before coming to this meeting to register their concern. Fishing Harbour will definelty bring growth but they must also consider that it will not bring any damage to the nearby villages.

15. Thiru.Arumugam, President, District Fishermen Society:

He stated that this project came into a reality after about 40 years of struggle. Rs.230 Crores was sanctioned for this project in the year 2019 by then Hon'ble Chief Minister Amma under Rule 110 Announcment in the Legislative Assembly for this project at Alamparaikuppam, Chengalpattu District and Azhagankuppam, Villupuram District,. The Hon'ble Minister for Fisheries knows how the fishermen fought for this harbour. The Government and officials had decided the implementation of this project by only after considering the pros and cons and how the people will get benefitted. Because of this project 20-25 villages and around 20000 families will get benefitted. This harbour is only for small boats not for big ships and launchers. The fishermen here have only small boats and fiber boats whose livelihood will get improved and hence Hon'ble Amma implemented the project. Harbour is proposed in deep areas whereas people who catch fish, prawn etc by using bare hands do only in shallow areas where the depth of water will be low and hence they will never get affected because of this Harbour.Some NGO's are bringing women from Villupuram district where already public hearing was conducted to stop this project by spreading false propaganda among the people. If they are really concerned they can raise those problems in that meeting where the officials might have considered and taken necessary steps to rectify. The livelihood of fishermen will improve and the income due to these fishing alone brings revenue around Rs.60000 crores to the Government in terms of foreign exchange by means of export. The Government implements such projects by spending huge amount to develop the livelihood of our people and to earn foreign exchange. The project will give the educated and unemployed people in this area the belief to buy boats and do fishing and to improve financially. So we all must cooperate and support collectively for implementing the project. He once again thanked the District administration and Fisheries department for giving the opportunity to air his views.

16. Thiru.V.Ramalingam,Sathurangapattinam, President, Chengalpattu District:

He welcomed the project and stated that villagers of both Alamparaikuppam and Azhagankuppam were giving petitions to the administration of Chengalpattu District and Villupuram District, fisheries department and to the Chief Minister asking for a fishing harbour. The present Government, particularly the Chief Minister has sanctioned Rs.650 crores for this developmental project which will improve the fishermen livelihood. The Government officials, District Collector, Revenue officials, Department of Fisheries and Environment must support for the implementation of this project which will not only improve the fishermen livelihood but will improve all the people in this area. No possibility of any damage because of this harbour and he requested the officials on behalf of the villagers and dalit womens to implement this project immediately for the welfare of the people.

17. Thiru.M.Gangadaran, Panaiyur, Edaikazhinadu Town Panchayat:

He welcomed the proposed project in Alamparaikuppam, Cheyyur Taluk, Chengalpattu District as the village will develop because of this project, employment opportunity will increase and fishermen livelihood improve.

18. Thiru.Ranjith Kumar, Alamparaikuppam:

He welcomed the project and stated that the project in the back water will improve the tourism as already lot of people visit the Alamparai fort in this area. He also stated that his ancestors had recorded that over 100 years before itself there was a harbour in Alamparaikuppam and this project must be considered as renovation of the old harbour. He thanked the officials for giving the opportunity.

19

Thiru.D.Vasudevan, District Environmental Engineer, TNPCB:

Finally, the District Environmental Engineer, Tamil Nadu Pollution Control Board thanked the gathering and stated that all their views/suggestions has been recorded by means of audio and video. The same along with their written submission will be forwarded to the Government for taking necessary further action.

The District Revenue Officer (FAC), Chengalpattu District thanked the gathering and stated that all their views/suggestions has been recorded by means of audio and video. The same along with their written submission will be forwarded to the Government for taking necessary further action.

Further, 10 Nos. of written submission during the time of public hearing and 3 Nos.receieved in the office of the District Environmental Engineer, TNPCB, Maraimalai Nagar are enclosed herewith.

District Environmental Engineer, Tamil Nadu Pollution Control Board, Maraimalai Nagar	District Revenue Officer(FAC) Chengalpattu District	District Collector, Chengalpattu

3/3

ANNEXURE-4

THE NEW INDIAN EXPRESS 10/12/2020

TAMILNADU POLLUTION CONTROL BOARD

PUBLIC NOTICE

Whereas, as per Environmental Impact Assessment Notification, 2006 as amended, Public Hearing has been made as mandatory for certain projects covered in Schedule of the said Notification.

Whereas, Public Hearing has to be conducted by State Pollution Control Board as per paras (2) and (3) of Appendix – IV of Environmental Impact Assessment Notification, 2006 as amended.

Whereas, as required under paras (2) and (3) of Appendix – IV of Environmental Impact Assessment Notification, 2006 as amended, public hearing is to be conducted by the Tamilnadu Pollution Control Board for the following project as below.

Name & Location of the Project	Date & Time	Place of Public Hearing
Proposed Construction of Fishing Harbour by Fisheries Department, Government of Tamilnadu in Kazhuveli Waters in an extent of 6.69.50 Hectares at S.F.No. 23/1& 23/2 of Azhagankuppam Village, Marakkanam Taluk, Villupuram District for Fish Catching of 12000 Tonnes/Annum.'	12.01.2021 & 10.30 A.M.	MJR Thirumana Mandapam, No. 131, Pondy Road, Marakkanam Post, Marakkanam Taluk, VillupuramDistrict PIN – 604303.

In this connection, it is informed that the Executive Summary of EIA in English & Tamil, draft EIA report in soft and hard copies of the above said project is made available for reference to the public in the following places.

1. Secretary to Government, Environment & Forest Department, St. George Fort, Secretariat, Chennai – 600 009. 2. The District Collector, Villupuram – 605 602. 3. District Industries Centre, Villupuram- 605602, VillupuramDistrict 4. The Executive Officer, Marakanam Town Panchayat, Marakkanam Post & Taluk, Villupuram District, Pin Code: 604 303. 5. The Block Development Officer, Marakanam Panchayat Union, Pondy Road, Marakkanam Post & Taluk Villupuram District Pin Code: 604 303. 6. The Librarian, Branch Library, Pondy Road, (Backside Town Panchayat Office) Marakkanam Post &Taluk, Villupuram District Pin Code: 604 303. 7. District Environmental Engineer, Tamil Nadu Pollution Control Board, District Collectorate Master Plan Complex, Villupuram – 605602. 8. The Member Secretary, Tamil Nadu Pollution Control Board, 76, Mount Salai, Guindy, Chennai – 600 032. 9. The Ministry of Environment, Forest and Climate Change, Regional Office (SEZ), 1st& 2nd Floor, Handloom Export Promotion Council, No. 34, Cathedral Garden Road, Nungambakkam, Chennai -34

Suggestions, views, comments and objections from the public are invited within 30 days from the date of publication of this notice by the District Environmental Engineer, Tamil Nadu Pollution Control Board, Villupuram.

All persons including bonafide resident, Environmental Groups and others located in the project site / sites of displacement / sites likely to be affected can participate in the Public Hearing and they can also make Oral / Written suggestions to the District Environmental Engineer, Tamil Nadu Pollution Control Board, Villupuram on the above subject.

Member Secretary,
Tamilnadu Pollution Control Board,
Chennai - 32.

DIPR/1213/DISPLAY/2020

ANNEXURE-5

17

MINUTES OF THE PUBLIC HEARING CONDUCTED FOR THE PROPOSED CONSTRUCTION OF FISHING HARBOUR BY TAMIL NADU FISHERIES DEPARTMENT, GOVERNMENT OF TAMILNADU IN KAZHUVELI WATERS AT S.F.NO. 23/1& 23/2 IN AN EXTENT OF 6.69.50 HECTARES OF AZHAGANKUPPAM VILLAGE, MARAKKANAM TALUK, VILLUPURAM DISTRICT FOR FISH CATCHING OF 12,000 TONNES/ANNUM ON 12.1.2021 AT 10.30 A.M. IN M/s. MJR THIRUMANA MANDAPAM, NO. 131, PONDY ROAD, MARAKKANAM POST & TALUK, VILLUPURAM DISTRICT.

1. Thiru. A. Annadurai, I.A.S	:	District Collector, Viluppuram District.
2. Tmt. Shreya P. Singh, I.A.S	:	Additional Collector Viluppuram District.
3. Dr. S. Anu, I.A.S.	:	Sub-Collector, Tindivanam, Viluppuram District
4. Thiru.S.Palanisamy	:	District Environmental Engineer, Tamil Nadu Pollution Control Board, Viluppuram.

PROJECT PROPONENTS

1. Thiru. M. Murugesan	:	The Executive Engineer, Tamil Nadu Fisheries Department, Chennai, Government of Tamil Nadu.
2. Thiru. P. Thiruvarul	:	The Assistant Executive Engineer, Tamil Nadu Fisheries Department, Cuddalore District Government of Tamil Nadu.

Public attended - 99 Nos. (List enclosed)

At the outset, the District Environmental Engineer, Tamilnadu Pollution Control Board, Villupuram has welcomed the District Collector, Additional Collector, Sub-Collector, Government officials, environmentalists and the public present in the public hearing meeting conducted on behalf of Tamilnadu Pollution Control Board. He informed that since the above Fishing Harbour project falls under the B1 Category and Schedule 7(c) of Environment Impact Assesment Notification No. S.O 1533 dated 14.09.2006 issued by the Ministry of Environment, Forest and Climate Change, it is necessary to conduct the public hearing to consider the issue of environmental clearance for the project. Hence, the public hearing meeting is now being conducted for the above said project as per the direction of State Environment Impact Assessment Authority. He also informed that the Public Notices were published in English and Tamil daily newspapers on 10.12.2020 with the approval of the District Collector, Villupuram for the conduct of this public hearing meeting. The detailed study report on Environment

Impact Assesment relating to the construction of the proposed fishing harbour project would be presented by the project proponents and their EIA Consultants through power point presentation to the public. The project proponent and the EIA Consultant will answer and give clarifications to the questions and informations raised on environmental issues by the public if any relating to the project. He has also requested the public to offer their views, opinions and suggestions about the proposed project after mentioning their name and place of their nativity. He informed that all the views and suggestions raised by the public in the meeting and the clarifications given by the project proponent and their EIA Consultant would be recorded in both audio and video and the same would be submitted to the State Environment Impact Assessment Authority for further necessary action. After his brief speech, he had requested the District Collector to preside over the public hearing meeting.

The District Collector has requested the project proponent and their EIA Consultant to present their proposed project details to the public through the power point presentation in detail.

Mr. Dinesh Kumar, Manager, DHI (India) Water and Environment Private Limited, New Delhi, the consultant of the project has welcomed all the gatherings and briefed about the proposed project with the help of power point presentation.

The District Collector requested the EIA Consultant representative to explain in Tamil language about the project so that the village people could understand and gave their comments and suggestions relating to the proposed project. Thiru.P. Thiruvarul, Assistant Executive Engineer, Fisheries Department, Cuddalore District has continued the power point presentation in Tamil in detail to the public.

After the technical presentation of the consultant, the District Environmental Engineer, Tamilnadu Pollution Control Board, Villupuram has requested the public present in the meeting to air their views regarding their opinions, doubts, apprehensions and suggestions regarding environmental issues only about the proposed fishing harbour project.

The District Collector, Villupuram has also requested the public present in the meeting to air their views regarding their opinions, doubts, apprehensions and suggestions regarding environmental issues only about the proposed fishing harbour project.

Accordingly, the following people and the Environmentalists have raised comments and questions in the public hearing meeting. The views and suggestions of the public are detailed as below.

1. **Thiru. Palani, Muttukadu Azhagankuppam:**
He welcomed the proposed project as it would fulfill the existence of Fishing Harbour in the Villupuram District. He also thanked the government and requested to bring the project to their village at the earliest.

2. **Thiru Sadhasivam, President, Fishing Cooperative Society, Kaipaanikuppam:**
He stated that this fishing harbor project is their livelihood project and welcomed the fishing harbor project.

3. **Thiru. A. Senkeni, Ekkiyarkuppam:**
He welcomed the fishing harbour project as their village fishermen had struggled a lot without a harbor in Villupuram district especially during the Thane Cyclone and other disaster happened in the past.

4. **Thiru. S. Subramani, Mandavaai Puthukuppam:**
He expressed his thanks to the Tamilnadu government and the District Collector for bringing this fishing harbor project in their district. Because they suffered a lot during the cyclones and they have to go to Pudhucherry Harbour to safeguard themselves in their small boat during the cyclones. He welcomed the project.

5. **Thiru. Gnanasekar, Panichamedu Kuppam:**
He said that he is a fisherman having small boat for fish catching purpose. He stated that he used to catch fishes in the nearby villages which brought lot of clashes between them and the nearby village fishermen. Hence, he welcomed the proposed fishing harbor in their district which would enhance livelihood of all the fishermen. He also requested to give employment to atleast one educated person belongs to fishermen community in each village in the proposed fishing harbor.

6. **Thiru. Gajendiran, Anumandhaikuppam:**
On behalf of village public and small boat association, he welcomed all the gatherings present in the meeting. He mentioned all the problems faced with the neighbouring state (Pudhucherry) fishermen while using their harbour in their state. Hence, he welcomed the proposed fishing harbor in their district and requested to give employment to the educated persons belongs to all their 19 villages in the proposed fishing harbor project.

7. **Thiru. Selvam, Chetti Nagar:**
He welcomed all the gatherings and stated that the announcement for the establishment of fishing harbour was made 15 years ago. But still there is no improvement in the implementation of this project. Hence, he requested the District Collector to bring this project at the earliest.

8. Thiru. R. Karthikeyan, Nochikuppam:

He welcomed all the gatherings and requested the government officials and the Ministers to implement the project without affecting the surrounding villages of the proposed location of the project. He also requested to do more studies relating to the project with respect to the EIA Notification, 2006 and shall implement the project. He welcomed by pointing out that the Government has assured to constitue the Port Management Committee and would ensure that one person from each village shall represent in the said Committee under the chairmanship of Director, Fisheries Department. He stated that the fishermen would stand to protect the Kazhuveli land and their village people in such a way that the fishing harbor project shall not affect them. He also insisted to strictly adhere to the Rules prescribed uinder EIA Notification, 2006 while implementing this project.

9. Thiru. N. Ganesan, Koonimedu Kuppam:

He requested to implement the fishing harbor project without affecting the surrounding villages of the project location.

10. Thiru. Sunanda Reddy, Environmentalist, Hyderabad:

He mentioned his support to the Fisheries Department for the proposed project. He informed that he would submit his views and suggestions in written form to the Management.

11. Thiru. K. Abishekam, Village President, Anichankuppam Village:

He expressed his gratitude and said that all the people of 19 villages felt happy for the implementation of this project.

12. Thiru. Aravindan, Bommaiyarpalayam:

He stated that all other districts are having fishing harbor except Viluppuram district. Hence, he welcomed the project on behalf of their 19 fishermen villages.

13. Thiru. Murugavel, Sodhanaikuppam:

He welcomed all the gatherings and stated that it is the dream project for all their 19 Villages and expressed his thankfulness to the Government. He also requested to implement the fishing harbor project immediately so as to enhnce their livelihood.

14. Thiru. Kandhan, Nochikuppam:

He welcomed the project and thanked all the Government officials, District Collector and the Hon'ble Minister for taking steps to bring the fishing harbor project in their district.

Er. P. Thiruvarul, Asst. Executive Engineer, TamilNadu Fisheries Department:

He thanked all the public who has welcomed the project. He replied to the question raised by one among the public that they have conducted detailed studies in 5 different locations by considering all the parameters and chosen this proposed location for implementing the fishing harbor project. He also replied that the project location is chosen near to the Sea shore as it would even help the large boats to access the harbor easily. Also, the project location would not affect the road development activities in future. He said that there is a separate police wing in the Fisheries Department itself and they would provide protection to all the fishermen in the Fishing Harbour as well as in the fish catchment area.

Finally, the District Environmental Engineer, Tamil Nadu Pollution Control Board has invited any other public willing to offer their views in this regard. Since there was no response from the public, it was decided to conclude the public hearing and he has thanked the public gathered and hence the public hearing meeting came to an end.

The District Collector, Viluppuram had received the petitions from the public which are enclosed. The list of public attended the public hearing meeting along with the Audio and Video of the entire proceedings is also enclosed.

4/2/2021

District Environmental Engineer
Tamil Nadu Pollution Control Board,
Villupuram

District Collector
Villupuram
4/2/2021

ANNEXURE-6

DB-25(37)

GOVERNMENT OF TAMILNADU
DEPARTMENT OF ARCHAEOLOGY

From,
Thiru.T.Udhayachandran. I.A.S.,
Principal Secretary /Commissioner,
Department of Archaeology,
Tamil Valarachi Valaagam,
Tamil Salai, Egmore,
Chennai – 600 008
Email Id:tnarch@tn.nic.in

To,
Director of Fisheries,
Integrated Office Complex,
Nandanam,
Chennai - 600 035.

Lr.No. C1/5336/2020, dated 18.01.2021

Sir,

Sub : Department of Archaeology - Development of Fisheries Harbour at Kazhuveli waters at Azhagankuppam in Villupuram District and Alamparaikuppam in Chengalpattu District - No Objection Certificate requested - Details Sent - Regarding.

Ref : Director of Fisheries, Chennai, Letter R.C.No.20716/C3/2017, Dated 15.12.2020.

--------------X--------------X--------------

With reference to your letter cited, it is informed that there is no State Archaeology protected monument falls in the proposed Construction of Fisheries Harbour at Kazhuveli waters at Azhagankuppam village in Villupuram District and also the proposed Construction of Fisheries Harbour at Alamparaikuppam in Chengalpattu District is beyond the limit of the regulated area from Alambarai Fort at Alambarai Village in Cheyyur Taluk of Chengalpattu District.

Sd/-
Principal Secretary/ Commissioner

//By Order//

Deputy Director 18/01/21

ANNEXURE-7

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 three months in the non-monsoon season between July 19th 2020 to October 9th 2020. Besides the baseline assessment undertaken as mentioned above, a one month monitoring was undertaken between 18th October 2019 to 11th November 2019 as well. The results of both the monitoring and sample analysis has been presented in this chapter. 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

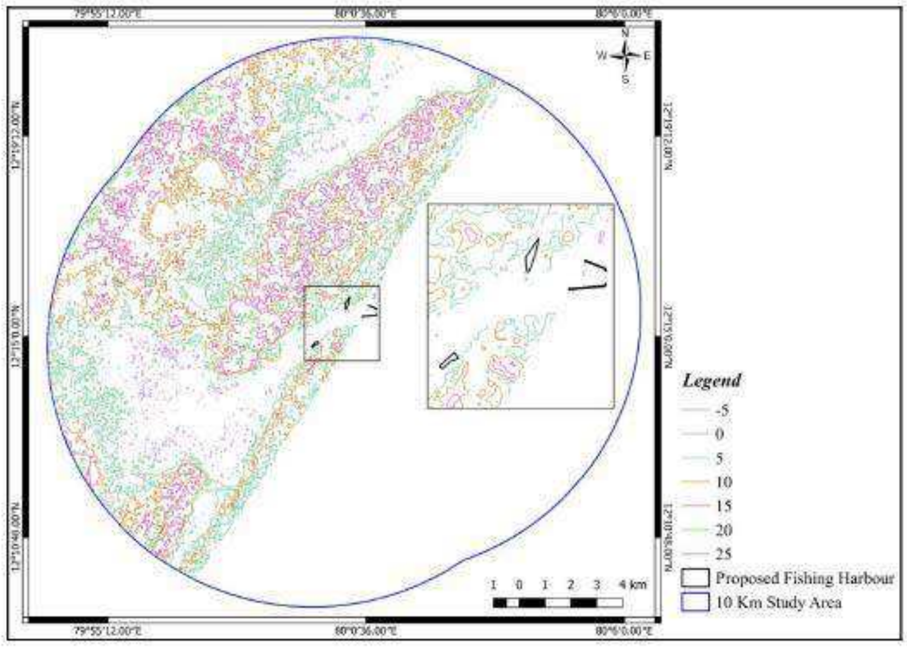
Viluppuram Dist.: The residual hills and denudational hills are common in Tirukoilur, Kallakurichi and Gingee taluks. Structural hills are noticed in the western part of the district. The shallow pediments and buried pediments are common in the central part of the district. Coastal areas are having older 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].

The contour map of the study area is presented in Figure 3-1.

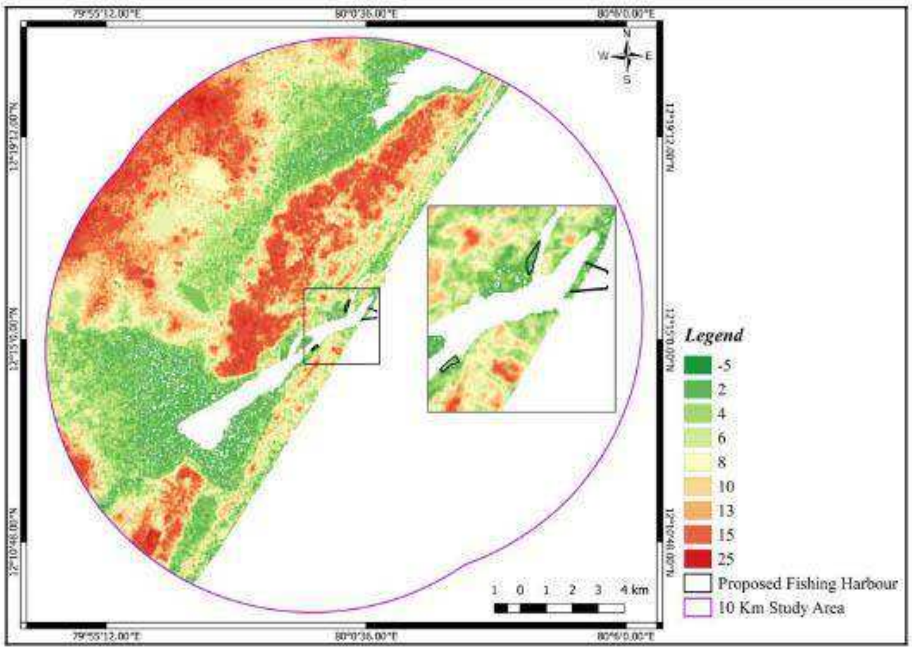
[1] District Groundwater Brochure, Villupuram district, Tamil Nadu, 2009.
[2] District Groundwater Brochure, Kancheepuram district, Tamil Nadu, 2007

Figure 3-1 Contour Map of the Study Area



The terrain maps of the study area is presented in Figure 3-2.

Figure 3-2 Terrain Map of the Study Area



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.

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 3-3 Methodology Chart

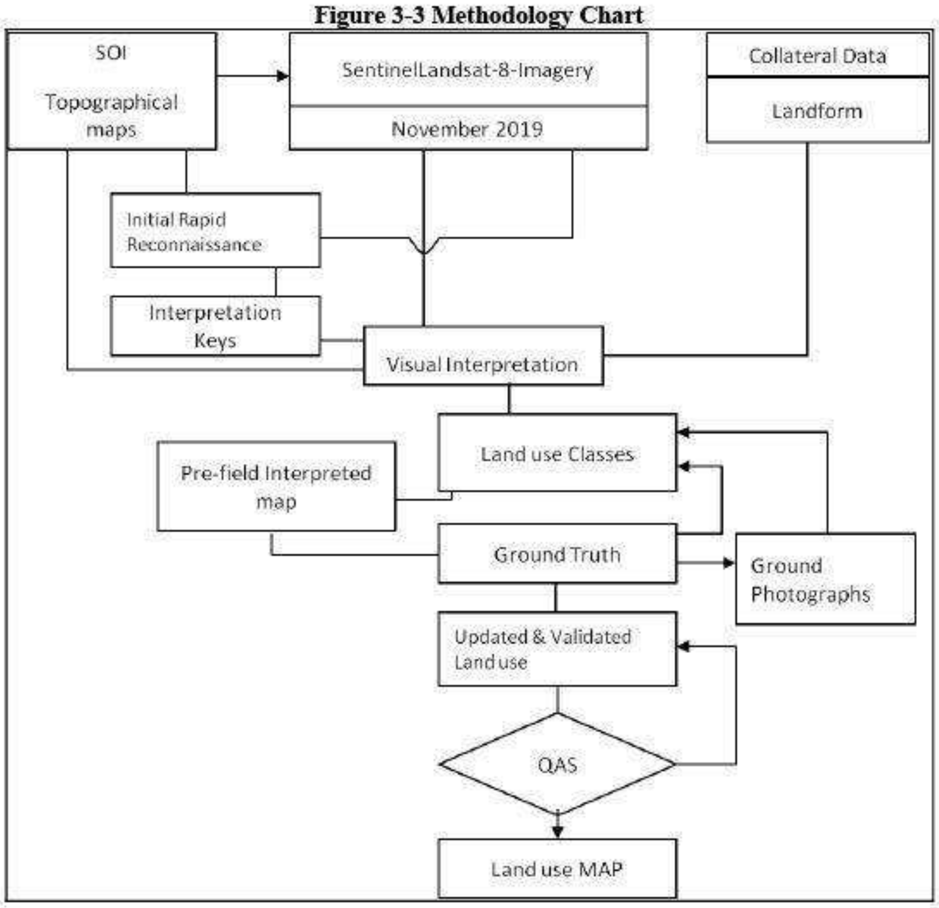
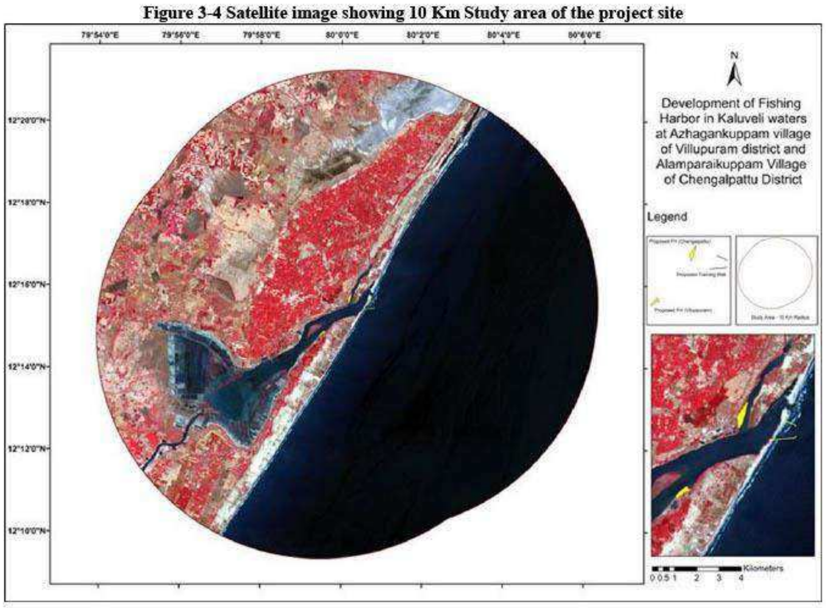


Figure 3-4 Satellite image showing 10 Km Study area of the project site



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 (6868.8 Ha) 34.23 % 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 (4276 Ha) 21.31 % 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 2058.7 Ha which is 10.26 % 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.
Seasonal water bodies and tidal influenced water bodies within the study area accounts to a total area of 983.7 Ha which is 4.9 % 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 614 Ha which is 3.06 % 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 681.3 Ha (3.4 %)

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

Level-I Classification	Area in Ha.	Area (%)
Wasteland	2058.7	10.26
Waterbody	983.7	4.90
Total	**20064.1**	**100**

Figure 3-5 Percentage of Land Use Distribution of the Study area

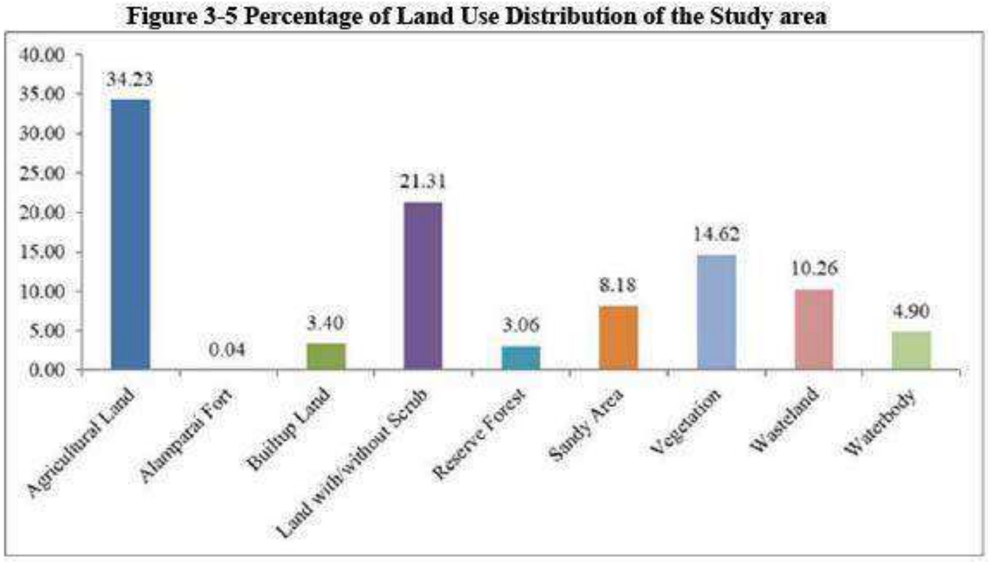
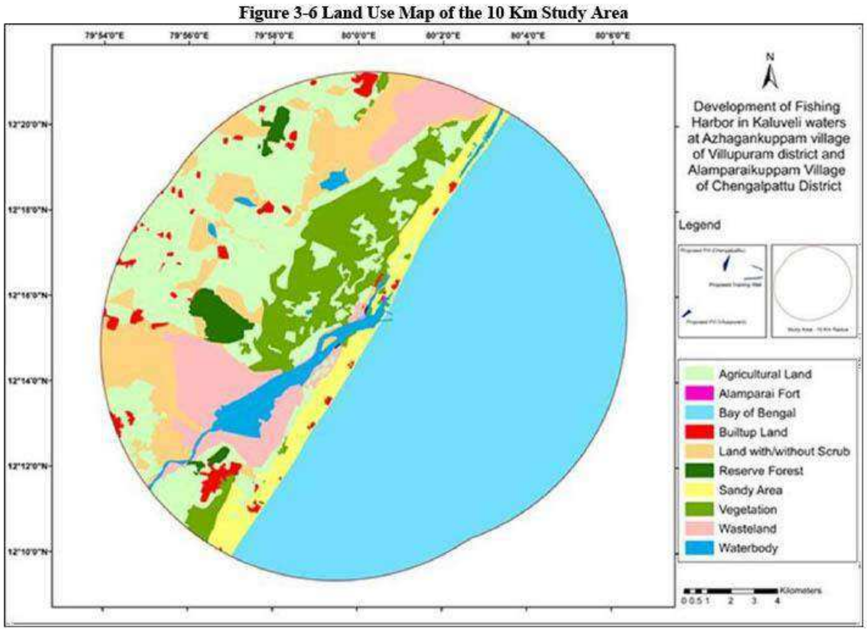


Figure 3-6 Land Use Map of the 10 Km Study Area



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].

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 within Study Area

The physicochemical and other characteristics of soil within the study area were analysed, and the samples were collected from 8 locations. 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 results of the soil samples in September 2020 is presented in Table 3-4 and the results of the samples collected in October 2019 is presented in present study of soil sampling and quality assessment shows the baseline conditions of the soil in the study and the results are presented in (Table 3-4).

[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.

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 3-7 Soil Sampling Locations within 10km Study Area

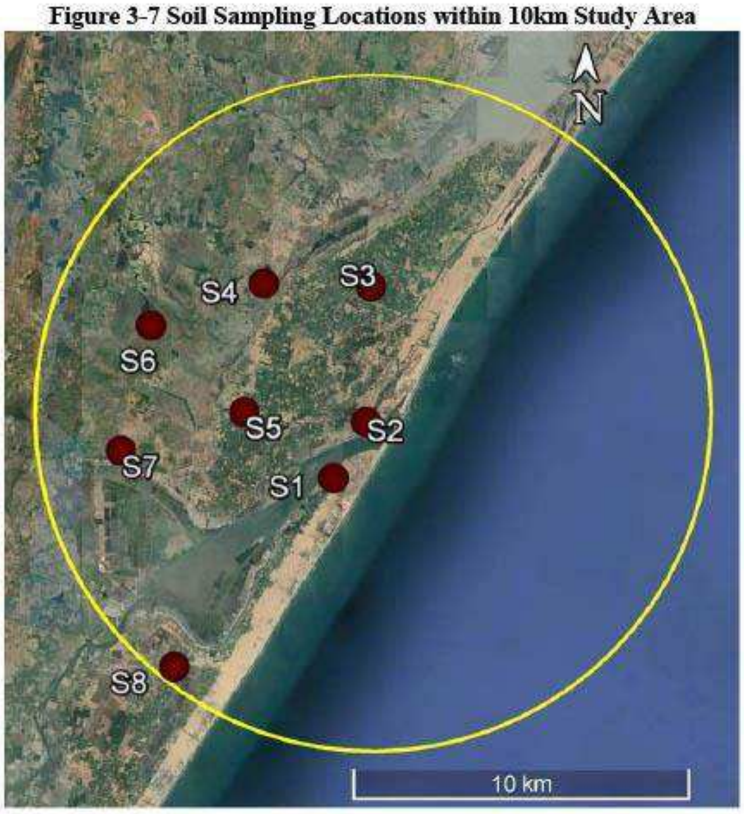


Table 3-4 Soil Quality of Study area – September 2020

S. No	Parameters	Unit	Soil - 1	Soil - 2	Soil - 3	Soil - 4	Soil - 5	Soil - 6	Soil - 7	Soil - 8
1	**Texture:**									
	Sand	%	60.5	16.2	22.5	27.8	31.3	19.7	32.3	23.6
	Silt	%	25.3	5.5	56.2	59.8	59.4	43.8	8	58.7
	Clay	%	14.2	78.3	21.3	12.4	9.3	36.5	59.7	17.7
2	pH	-	6.1	7.9	6.3	7.2	6.1	7.1	7.8	5.1
3	Moisture	%	9.46	38.73	13.76	21.47	8.46	7.42	10.76	7.44
4	Conductivity	µs/cm	388	17730	284	580	278	410	10200	268
5	Specific gravity	g/cm^3	1.43	1.12	1.48	1.38	1.54	1.46	1.16	1.43
6	Bulk Density	g/cm^3	1.43	1.12	1.48	1.38	1.54	1.46	1.16	1.43
7	Sodium Absorption Ratio	-	4.6	31.6	5.7	6.5	7.1	4.6	12.3	5.17
8	Water Holding Capacity	%	22	18	20	22	20	24	18	20
9	Porosity	%	32	40	28	30	30	36	40	32
10	Available Nitrogen	mg/kg	116	257	310	342	290	332	238	294
11	Nitrate Nitrogen	mg/kg	17.3	32.6	28.7	32.3	32.6	28.7	21.6	26.7
12	Available Phosphorus as P	mg/kg	47.6	58.8	61.3	72	92	41.8	34.7	48.2
13	Available Potassium	mg/kg	120	314	74.5	138	160	216	134	106
14	Calcium as Ca	mg/kg	20	274	56	38	40	64	216	44
15	Magnesium as Mg	mg/kg	32	3792	25	42	12	30	393	22
16	Acidity as $CaCO_3$	mg/kg	24	2	18	6	10	6	Nil	14
17	Alkalinity as $CaCO_3$	mg/kg	84	168	103	210	94	108	162	26
18	Sulphate Sulphur as S	mg/kg	11	1602	10.2	10.6	12.6	34	1032	28.4
19	Boron as B	mg/kg	0.98	7.2	0.94	0.86	1.1	0.52	2.7	0.74
20	Chloride as Cl	mg/kg	62	15730	44	58	62	93	7230	44
21	Sodium as Na	mg/kg	90	8350	104	46	193	234	2518	104

S. No	Parameters	Unit	Soil - 1	Soil - 2	Soil - 3	Soil - 4	Soil - 5	Soil - 6	Soil - 7	Soil - 8
22	Total Organic Carbon	%	0.21	1.12	0.28	0.16	0.17	0.32	0.72	0.21
23	Iron as Fe	%	0.26	0.79	0.32	0.46	0.68	0.76	0.73	0.58
24	Zinc as Zn	mg/kg	24.76	31.42	31.6	22.56	35.45	34.74	24.11	22.99
26	Manganese as Mn	mg/kg	31.4	68.4	40.6	53.8	48.9	62.1	74.8	56.23

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

Table 3-5 Soil Quality of Study area – October 2019

S.No	Parameters	Units	S1	S2	S3	S4	S5	S6	S7	S8
1.	**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
2.	pH	-	6.4	8.0	6.8	6.4	6.9	7.6	5.6	5.1
3.	Moisture	%	8.62	14.22	6.32	6.52	4.66	12.71	4.06	4.72
4.	Conductivity	µs/cm	417	826	321	662	337	481	108	316
5.	Specific gravity	g/cm^3	1.74	1.62	1.68	1.36	1.62	1.50	1.36	1.48
6.	Porosity	%	24	26	36	32	32	38	26	34
7.	Sodium as Na	mg/kg	48.4	4645	36.8	884	41.6	207	12.5	36.9
8.	Available Nitrogen	mg/kg	126	142	396	410	328	412	138	378
9.	Nitrate Nitrogen	mg/kg	21.4	28.7	36.2	41.7	41.82	36.7	17.6	32.4
10	Available Phosphorus as P	mg/kg	62.4	67.2	74.2	88	111	50.2	48.2	67.1
11	Calcium as Ca	mg/kg	16	80	40	26	46	62	12	36
12	Magnesium as Mg	mg/kg	20	292	24	34	14	22	18	16

S.No	Parameters	Units	S1	S2	S3	S4	S5	S6	S7	S8
13	Acidity as $CaCO_3$	mg/kg	12	Nil	8	10	6	3	21	28
14	Alkalinity as $CaCO_3$	mg/kg	96	214	104	306	118	134	68	50
15	SulphateSulphur as S	mg/kg	8.8	6.5	13.4	14.4	18.3	22.1	17.4	39.3
16	Boron as B	mg/kg	1.3	0.8	0.6	0.4	0.8	0.4	1.6	0.7
17	Total Organic Carbon	%	0.17	0.12	0.26	0.24	0.22	0.36	0.18	0.33
18	Chloride as Cl	mg/kg	49	244	52	66	73	24	62	42
19	Sodium Absorption Ratio	-	5.8	10.2	6.1	7.2	6.7	5.4	7.8	4.8
20	Bulk Density	g/cm^3	1.74	1.62	1.68	1.36	1.62	1.50	1.36	1.48
21	Water Holding Capacity	%	12.6	13.9	17.8	20.9	16.4	18.1	12.3	17.2
22	Available Potassium	mg/kg	149	820	84.4	153	182	542	63.6	123
23	Iron as Fe	%	0.18	0.41	0.25	0.35	0.21	1.22	0.06	0.19
24	Manganese as Mn	mg/kg	15.59	48.65	29.46	42.66	22.20	47.63	14.74	42.20
25	Zinc as Zn	mg/kg	12.72	14.97	22.35	18.88	8.46	36.34	7.23	9.65
26	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,

3.2.3.2 Soil Analysis Result – September 2020

The predominant composition of the soil within the study area was observed to be silt. The pH of all the collected soil samples was found to be varying from 5.1-7.9. Slightly acidic pH (5.1) was observed for location 8 and location 2 had pH of 7.9. The pH in the range from 5- 8 is considered good for the growth of plants. The moisture content ranged from 7.42- 38.73%. Maximum moisture content was observed for sample location 2 and minimum was observed at location 1. The water holding capacity of the samples was found to be ranging from 18-24%, with a bulk density ranging between occurred between 1.12-1.54 g/cm^3.

Calcium concentration for all the samples was found to be ranging from 20-274 mg/kg. The highest concentration of calcium occurred at location 2. Sodium concentration as Na was found to be ranging from 46-8350 mg/kg. Highest sodium concentration was observed for location 2 and lowest was observed for location 4. Soil S2 and S7 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 the tidal influenced Kaluveli estuary and therefore could be saline in nature which might result in increase in concentration of mineral nutrients in the soil.

The acidity as CaCO3 ranged from 2-24 mg/kg. The concentration was found to be nil in location 7. Alkalinity as CaCO3 was found to b ranging from 26-210 mg/kg. Highest concentration was observed for location 4 and lowest was observed for location 8. The concentration of available nitrogen ranged from 116-342 mg/kg. Highest concentration was observed for location 4 and lowest was observed for location 1. Nitrate nitrogen concentration ranged from 17.3-32.6mg/kg. Available Phosphorus ranged from 34.7-92 mg/kg. Available Potassium ranged from 74.5-314 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.

The iron concentration was found to be between 0.26-0.79 percent. The concentration of manganese ranged from 31.4-74.8mg/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 V**.

3.2.3.3 Soil Analysis Result – October 2019

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 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/cm3.

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. 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 CaCO3 ranged from 3-28 mg/kg. The concentration was found to be nil or sample location 2. Alkalinity as CaCO3 was found to b ranging from 50-306 mg/kg. Highest concentration was observed for location 4 and lowest was observed for location 8. 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. 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 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 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 V**.

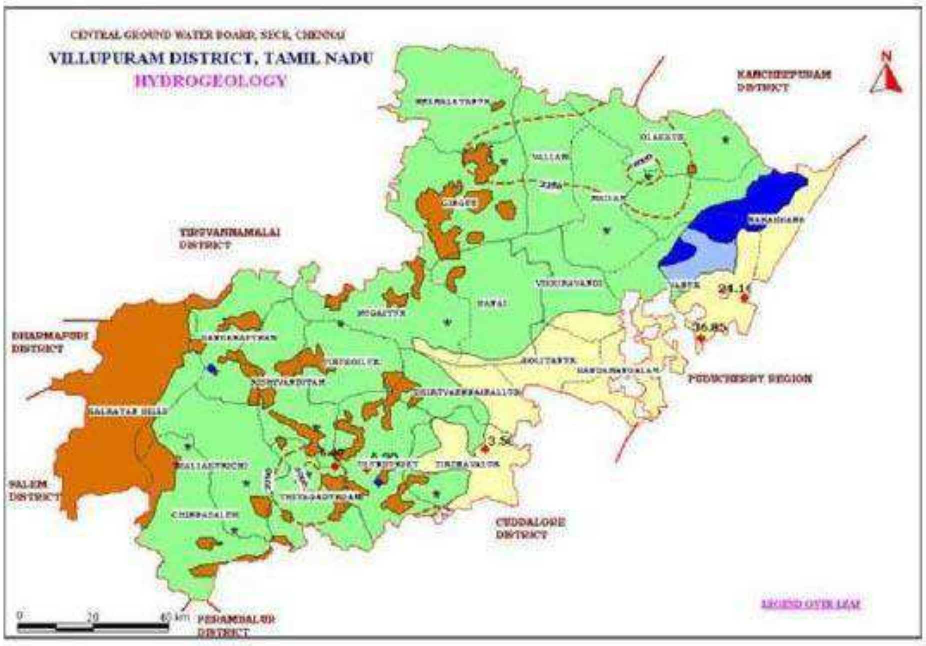
3.2.4 Hydrogeology

Villupuram 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.

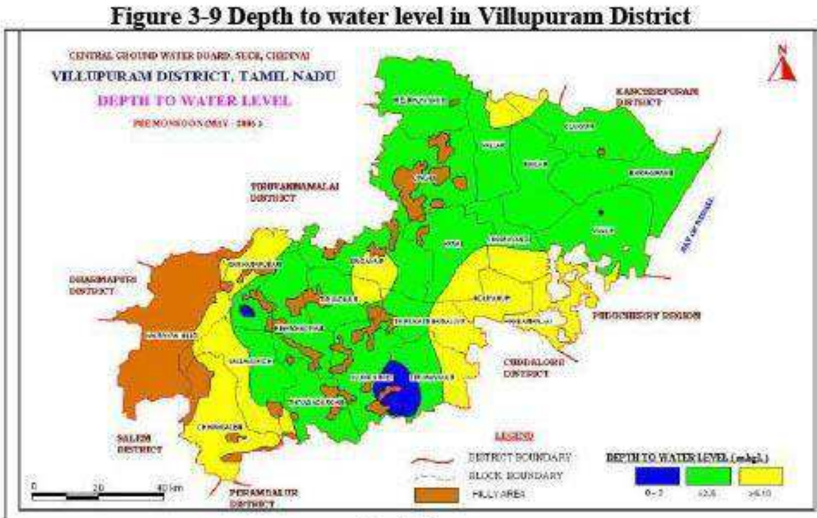
during pre-monsoon (May 2006) and it varies from 0.7 to 4.45 m bgl during post monsoon (January 2007). During pre-monsoon, the depth to water levels in the range of >2 to 5 m bgl in major part of the district, in the range of >5 -10 m bgl in western and southeastern parts of the district and range of 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 3-8 Hydrogeology of Villupuram District

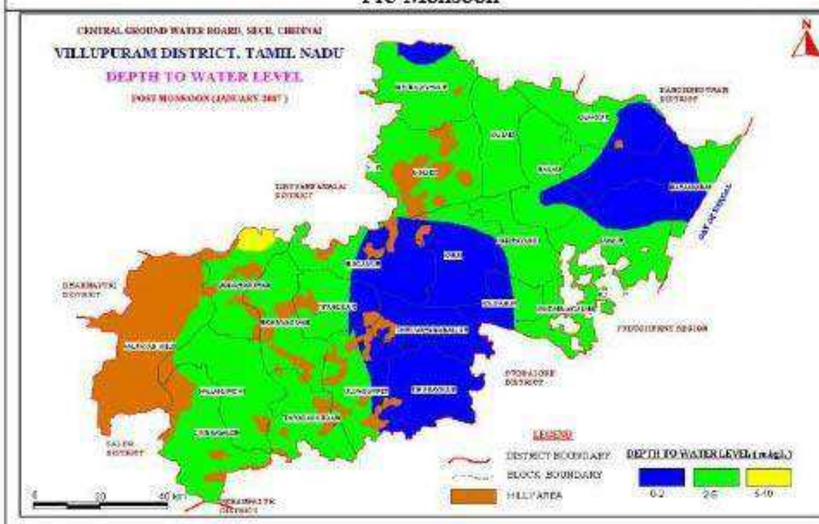


The ground water is being developed my means of dug wells, bore wells and tube wells. The diameter of the well is in the range of 7 to 10 m and depth of dug wells range from 15 to 18 m bgl depending on the weathered thickness and joints. The dug wells yield up to 1 lps in summer months and few wells 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 3-9 Depth to water level in Villupuram District



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 3-10 Figure showing Hydrogeology of Kancheepuram District

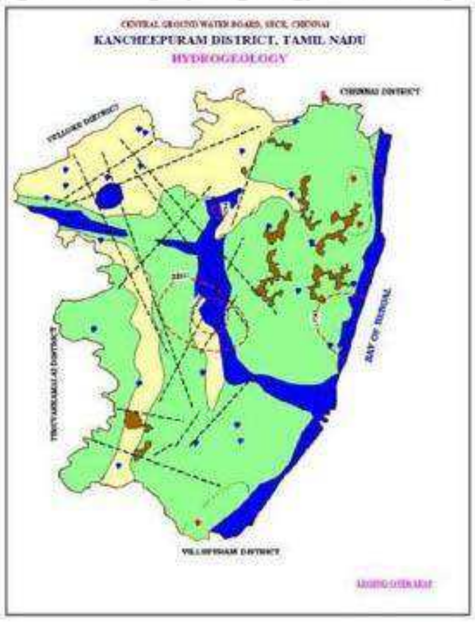
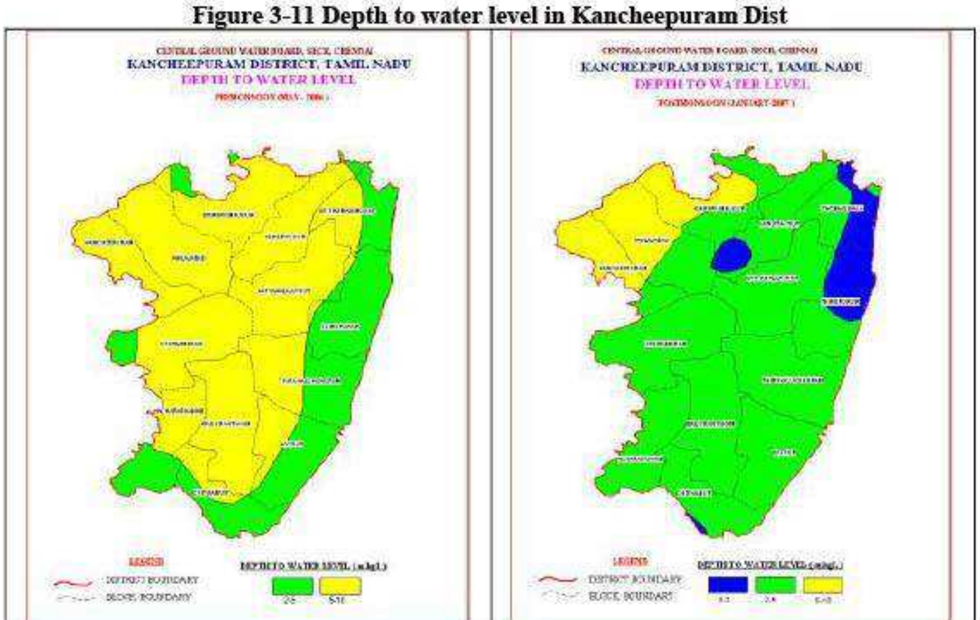


Figure 3-11 Depth to water level in Kancheepuram Dist



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 Groundwater Quality

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 $CaCO_3$ 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 litho units constituting the aquifers in the district, whereas the Nitrate pollution is most likely due to the use of pesticides

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

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 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 3-6. The water quality monitoring stations are shown in Figure 3-12. The summary of the samples collected in September 2020 is presented in Table 3-7 and the samples collected in October 2019 is given in Table 3-8. The lab analysis test report is given in **Annexure VI**. 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 3-6 Geo coordinates for groundwater sampling location

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

[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.*

S.No	Station	Location Name	Site Coordinate
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

Figure 3-12 Groundwater Sampling Locations within 10km Study Area

Table 3-7 Groundwater Quality of study area – September 2020

S.NO	PARAMETERS	UNITS	Ground Water-1	Ground Water-2	Ground Water-3	Ground Water-4	Ground Water-5	Ground Water-6	Ground Water-7	Ground Water-8
1	Salinity	ppt	0.38	0.29	1.37	1.92	0.114	0.4	0.302	0.458
2	Colour	HU	2	5	5	2	5	5	2	5
3	Odour	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
4	Taste	-	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Agreeable	Disagreeable
5	Turbidity	NTU	3	11	4	< 1	14	3	< 1	12
6	pH @ 25°C	-	7.2	4.3	7.5	7.3	5.6	7	6.6	6.3
7	Conductivity @ 25°C	µs/cm	640	523	2231	3314	178	701	503	763
8	Total Hardness as $CaCO_3$	mg/l	80	60	716	722	12	143	51	83
9	Chloride as Cl^-	mg/l	97	121	622	692	24	115	118	110
10	Total Residual Chlorine	mg/l	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
11	Total Dissolved Solids	mg/l	382	298	1370	1926	114	404	302	458
12	Total Suspended Solids	mg/l	2	7	6	< 2	6	5	< 2	4
13	Oil & Grease	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
14	P. Alkalinity as $CaCO_3$	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
15	Total Alkalinity as $CaCO_3$	mg/l	132	< 2	187	211	9	114	22	128
16	Calcium as Ca	mg/l	19	11	137	133	3	39	12	25
17	Sodium as Na	mg/l	102	67	230	287	18	86	68	80
18	Potassium as K	mg/l	13	3.4	6.7	198	1.8	7.1	13	61
19	Magnesium as Mg	mg/l	8	8	91	95	1	11	5	5
20	Sulphate as SO_4	mg/l	36	19	109	251	9	51	19	31
21	Nitrate as NO_3	mg/l	9.1	18.3	14.5	24	0.9	5.4	6.7	12.7
22	Fluoride as F	mg/l	0.12	0.16	0.33	0.39	BDL(DL:0.1)	0.13	BDL(DL:0.1)	0.12
25	Mineral oil	mg/l	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
26	Boron as B	mg/l	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)
27	Iron as Fe	mg/l	0.29	1.8	0.48	0.06	0.61	0.26	0.1	1.1
30	Dissolved Oxygen	mg/l	6.9	6.6	6.8	6.8	6.9	6.8	6.9	6.8
31	Silica as SiO2	mg/l	6.8	31	40	75	43	6.9	35	53
32	Biochemical Oxygen Demand (BOD) 3 days @ 27°C	mg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
33	Chemical Oxygen Demand (COD)	mg/l	< 4	8	< 4	< 4	< 4	< 4	< 4	< 4
35	Copper as Cu	mg/l	BDL(DL:0.02)	0.04	BDL(DL:0.02)	BDL(DL:0.02)	BDL(DL:0.02)	BDL (DL:0.02)	BDL (DL:0.02)	BDL(DL:0.02)
38	Zinc as Zn	mg/l	BDL(DL:0.08)	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)
39	Manganese as Mn	mg/l	BDL(DL:0.01)	0.15	0.03	BDL(DL:0.01)	0.09	0.04	BDL (DL:0.01)	0.11
45	Total Coliform	MPN/100 ml	Absent	Absent	Present	Present	Absent	Present	Absent	Present

Table 3-8 Groundwater Quality of study area – October 2019

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 – September 2020

The pH of all the collected ground water samples was found to be varying from 4.3-7.5. PH value of 4.3 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. 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, except for the one collected from location 7. Turbidity of the samples was found to be ranging between <1-14 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 for GW2 and GW5 could be due to the fact that sample GW2 lies very close to coast which might result in turbid waters. Total suspended solids ranged from <2-7mg/l whereas the total dissolved solids ranged between 114-1926 mg/l. The total hardness was found to range from 12-722mg/L. Calcium concentration for all the samples was found to be ranging from 3-137 mg/L. The conductivity of the ground water samples ranged from 178 μs/cm for GW-5 location and 3314 μs/cm for location GW-1.

Dissolved oxygen ranged from 6.6-6.9 mg/L, and the concentration of COD was found to be less than 4 mg/L for all the samples, except for location2 with 8mg/L. The BOD (at 27 °C for 3 days) was found to be less than 2 for all the set of 8 samples. The iron concentration was found to be between 0.06-1.8 mg/L. The concentration of oil and grease was found to be less than 2 mg/L for all the set of samples.

3.2.5.4 Groundwater Quality – October 2019

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 reason 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. 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. 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.

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.

3.2.6 Drainage and Surface Water

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 could not 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 3-9 and the locations marked in Google Earth are shown in **Figure 3-13.** The summary of the analysed Surface water results are shown in **Table 3-10**. The results of the surface water samples are attached as **Annexure VII.** 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 3-9 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

[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*

Figure 3-13 Surface Water Sampling Locations

Table 3-10 Surface water quality of study area – September 2020

S.No	Parameters	Units	Surface Water-2	Surface Water-3	Surface Water-4	Surface Water-5	Surface Water-6	Surface Water-8
1	Salinity	ppt	0.182	0.068	0.066	0.108	50.5	1.664
2	Colour	HU	20	5	5	30	5	2
3	Odour	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
4	Taste	-	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable	Disagreeable
5	Turbidity	NTU	42	5	8	11	7	3
6	pH @ 25°C	-	6.7	7.4	7.4	7.3	8.5	7.5
7	Conductivity @ 25°C	µs/cm	304	115	104	175	83100	2780
8	Total Hardness as $CaCO_3$	mg/l	47	31	30	46	16822	552
9	Chloride as Cl^-	mg/l	63	2	6	24	28130	802
11	Total Dissolved Solids	mg/l	182	68	66	108	50520	1664
12	Total Suspended Solids	mg/l	12	7	4	13	9	4
13	Oil & Grease	mg/l	< 2	< 2	< 2	< 2	< 2	< 2
14	P. Alkalinity as $CaCO_3$	mg/l	Nil	Nil	Nil	Nil	12	Nil
15	Total Alkalinity as $CaCO_3$	mg/l	37	31	33	42	110	66
16	Calcium as Ca	mg/l	8	6	7	12	529	137
17	Sodium as Na	mg/l	37	5	5	16	13940	371
18	Potassium as K	mg/l	10	2	5	5	1622	28
19	Magnesium as Mg	mg/l	6	4	3	4	3770	51
20	Sulphate as SO_4	mg/l	8	3	2.5	5	2398	191
21	Nitrate as NO_3	mg/l	5.3	9.5	3.2	7.6	0.82	15.7
22	Fluoride as F	mg/l	0.36	0.16	BDL(DL:0.1)	0.14	0.58	0.26
25	Mineral oil	mg/l	Absent	Absent	Absent	Absent	Absent	Absent
26	Boron as B	mg/l	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	3.6	BDL(DL:0.1)
27	Iron as Fe	mg/l	4	0.77	0.25	2.8	0.4	0.36
29	Hexavalent Chromium as Cr^{6+}	mg/l	BDL (DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL(DL:0.01)	BDL (DL:0.01)	BDL(DL:0.01)
30	Dissolved Oxygen	mg/l	6.6	6.9	6.8	6.7	6.6	6.8
31	Silica as SiO_2	mg/l	15	9.1	10	3	1	6.2
32	Biochemical Oxygen Demand (BOD) 3 days @ 27°C	mg/l	< 2	< 2	< 2	< 2	20	< 2
33	Chemical Oxygen Demand (COD)	mg/l	< 4	< 4	< 4	< 4	152	< 4
38	Zinc as Zn	mg/l	BDL(DL:0.08)	BDL(DL:0.08)	BDL(DL:0.08)	0.1	0.14	BDL(DL:0.08)
39	Manganese as Mn	mg/l	0.16	0.06	BDL (DL:0.01)	0.26	0.13	0.04
45	Total Coliform	MPN/100 ml	Present	Absent	Present	Present	Absent	Present

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

Table 3-11 Surface water quality of study area – October 2019

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

3.2.6.2 Surface Water Quality – September 2020

The surface water sampling was done for location 2, 3, 4, 5, 6 and 8. The pH of all the collected surface water samples was found to be varying from 6.7-8.5. 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.

Total suspended solids ranged from 4-13mg/l and the total hardness was found to be ranging from 39-16822 mg/L. Lowest concentration occurred for location SW-6 and highest occurred for SW-6. The total dissolved solids ranged between 68 and 50520 mg/l. Highest concentration of Total dissolved solids was observed for Sample location SW-6 and lowest for SW-4. The excessively high values for SW-6 could be due the presence of aquaculture ponds and salt 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 concentration of chlorides ranged from 2-28130 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 5-13940 mg/L. Highest concentration was observed for location SW-6 and lowest was observed for location SW-3&4. The conductivity of the surface water samples ranged from 104 µs/cm for SW-4 location to 83100 µs/cm for location SW-6.

The Dissolved Oxygen ranged from 6.6-6.9 mg/L. The concentration of COD was found to be less than 4 mg/L for all the set of samples, except for location 6 with 152 mg/l. The BOD (at 27 °C for 3 days) was found to be less than 2 for all the set of 8 samples, except for location 6 with 20 mg/l.

Iron concentration occurred from 0.25- 4 mg/L for all the set of samples, where highest concentration was observed at location 2. The concentration of copper was found to be below detectable limit except for location 6 with 0.09 mg/l. 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. The concentration of oil and grease was found to be less than 2 mg/L for all the set of samples.

3.2.6.3 Surface Water Quality – October 2019

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.

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. 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. 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 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.

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.

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

Villupuram 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 41 °C. The humidity is also high in the order 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 3-12 IMD - Climatology Table for Pondicherry Observatory – Temperature & Rainfall

Month	Temperatures (°C)				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	29.6	22.1	33.5	15.1	83 80	31	1.4	80	4,1985	12.3
Feb	30.5	22.5	34.5	16.5	80 80	8.1	0.9	68.6	6,1984	12.8
Mar	31.7	24	35	19.5	77 77	9.9	0.6	134.5	9,1971	13.2
Apr	33.1	25.9	38	21.9	74 74	9.2	0.4	71	13,1996	14.4
May	34.7	27	43	21.3	71 72	52	1.7	183	7,1981	13.5
Jun	36	26.6	42.5	21.5	70 69	58.8	2.7	106.8	5,1985	11.5
Jul	34.6	25.7	45.5	18.9	74 73	80.5	4.8	140	28,1981	10.3
Aug	34	25.2	39	20.4	76 73	130.7	6.6	118.6	16,1997	10
Sep	33.4	24.8	39	20.5	77 75	131.7	6.8	107	17,1979	10.4
Oct	32	24.5	36.5	18.8	80 77	229.3	9.6	188	29,1991	10
Nov	30.1	23.6	35	19.5	83 80	351	11.1	319.2	4,1978	10.8
Dec	29.6	22.6	37.3	16.5	84 81	242	6.2	178	21,1994	12.8
Annual Total / Mean	32.4	24.5	45.5	23	77	1334.1	52.9	319.2	4, 1978	11.8

Table 3-13 IMD - Climatology Table for Pondicherry Observatory – Wind Speed & Direction

Month	No. of days with wind speed (kmph)				Percentage no. of days wind from								
	62 or more	20-61	01-19	0	N	NE	E	SE	S	SW	W	NW	Calm
Jan	0	0	31	0	7	35	1	5	0	5	1	46	0
	0	10	21	0	1	55	0	9	0	3	0	32	0
Feb	0	0	28	0	4	30	0	14	1	8	1	42	0
	0	12	16	0	1	36	1	32	0	6	0	24	0
Mar	0	0	31	0	1	18	0	33	1	21	1	24	1
	0	13	18	0	0	23	1	52	0	11	0	13	0
Apr	0	0	30	29	0	7	1	56	4	24	1	7	0
	0	14	16	0	0	7	0	72	0	17	0	4	0
May	0	0	31	0	0	2	0	44	3	38	2	11	0
	0	11	20	0	0	5	0	69	1	20	0	5	0
Jun	0	0	30	0	0	2	0	23	1	54	5	15	0
	0	9	21	0	0	7	0	49	1	33	1	9	0
Jul	0	0	31	0	0	3	0	20	1	56	4	16	0
	0	8	23	0	0	5	0	49	0	37	1	8	0
Aug	0	0	31	0	0	3	0	17	0	56	2	22	0
	0	8	23	0	0	7	0	51	0	32	0	10	0
Sep	0	0	30	0	0	3	0	28	0	47	0	22	0
	0	9	21	0	0	10	0	53	0	28	0	9	0
Oct	0	0	31	0	1	16	0	19	0	31	1	31	1
	0	8	23	0	0	25	0	39	0	19	0	17	0
Nov	0	0	30	0	3	32	0	10	0	9	0	46	0
	0	9	21	0	1	43	0	17	0	6	0	33	0
Dec	0	1	30	0	6	35	0	9	0	4	0	46	0
	0	13	18	0	1	51	0	11	0	6	0	31	0

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.

Villupuram 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 3-12**.

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 3-14 Rainfall Data -Viluppuram District from 2014 - 2018 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 3-15 Rainfall Data -Kancheepuram District from 2014 - 2018 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

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 wind rose plot of Pondicherry region plotted for the months between July and September, the period for which the baseline monitoring was undertaken, with 30 years average data by IMD is shown in **Figure 3-12.** And the site specific wind rose plot based on the meteorological data collected during the three month monitoring between July 2020 to September 2020 is presented in Figure.

Figure 3-14 Pondicherry Annual Wind Rose Plot IMD data

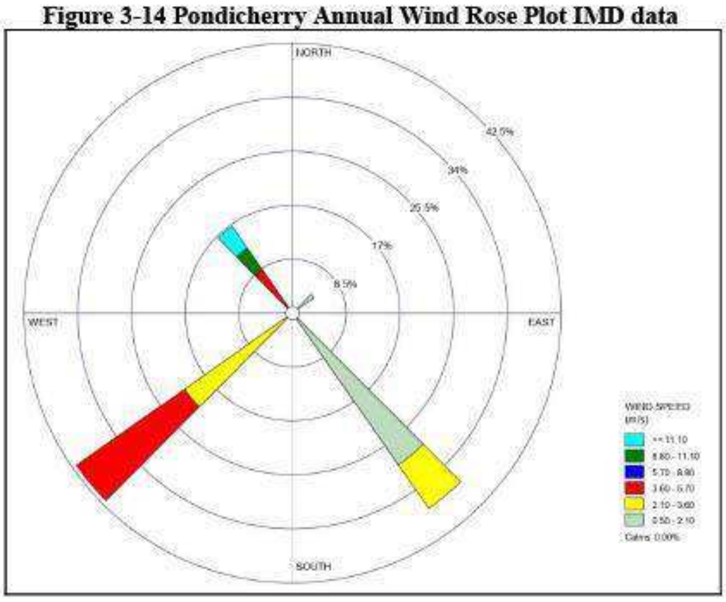
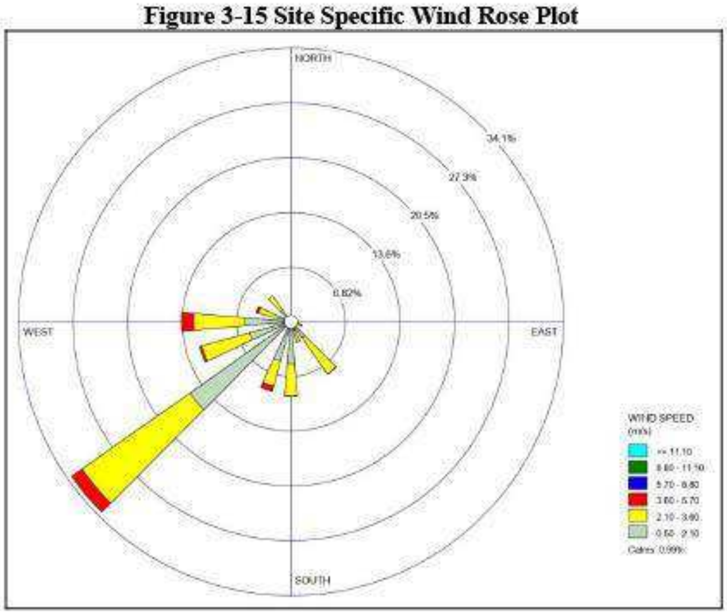


Figure 3-15 Site Specific Wind Rose Plot



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 3-16. The sampling co-ordinates of the AAQ monitoring locations are given in Table 3-16 and the sampling locations represented on Google Map shown in Figure 3-17. 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 3-18**.

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 3-16 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.

Table 3-16 Air and Noise Monitoring Locations

S.No	Station Air	Name of the Location	Latitude	Longitude
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

S.No	Station Air	Name of the Location	Latitude	Longitude
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 3-17 AAQ Monitoring Locations

Table 3-17 Ambient Air Quality Monitoring Results – July – October 2020

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/m³	60	16.2	33.5	10.0	20.1	10.0	18.6	15.2	24.8	23.6	34.1	13.4	24.5	21.1	33.5	20.1	29.5
2	Particulate Matter (PM_{10})	µg/m³	100	38.6	74.1	29.6	48.5	27.1	41.5	36.5	56.6	53.8	74.2	32.5	53.5	49.2	69.2	45.5	63.4
3	Sulphur Dioxide (SO_2)	µg/m³	80	BDL	9.5	BDL				BDL	6.8	7.8	14.5	BDL	7.8	5.2	10.2	4.2	10.2
4	Oxides of Nitrogen (NO_2)	µg/m³	80	6.5	16.2	BDL	7.5	BDL	5.7	7.5	15.2	14.5	27.1	4.7	15.1	13.5	24.1	11.4	21.5
5	Ozone (O_3)	µg/m³	180	BDL	13.6	BDL				BDL	12.1	16.1	30.1	BDL	13.2	9.2	17.1	10.1	23.8
6	Carbon Monoxide (CO)	mg/m³	4	BDL															
7	Ammonia (NH_3)	µg/m³	400	BDL				BDL	10.5	BDL	12.5	10.6	30.1	BDL	11.5	10.5	24.5	13.5	26.1

Table 3-18 Ambient Air Quality Monitoring Results – October 2019

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/m³	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/m³	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/m³	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/m³	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/m³	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/m³	4	BDL(DL:1.15)															
7	Ammonia (NH_3)	µg/m³	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.

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 (PM2.5)	µg/m^3	60	16.2	33.5	10.0	20.1	10.0	18.6	15.2	24.8	23.6	34.1	13.4	24.5	21.1	33.5	20.1	29.5
2	Particulate Matter (PM10)	µg/m^3	100	38.6	74.1	29.6	48.5	27.1	41.5	36.5	56.6	53.8	74.2	32.5	53.5	49.2	69.2	45.5	63.4
3	Sulphur Dioxide (SO2)	µg/m^3	80	BDL	9.5	BDL				BDL	6.8	7.8	14.5	BDL	7.8	5.2	10.2	4.2	10.2
4	Oxides of Nitrogen (NO2)	µg/m^3	80	6.5	16.2	BDL	7.5	BDL	5.7	7.5	15.2	14.5	27.1	4.7	15.1	13.5	24.1	11.4	21.5
5	Ozone (O3)	µg/m^3	180	BDL	13.6	BDL				BDL	12.1	16.1	30.1	BDL	13.2	9.2	17.1	10.1	23.8
6	Carbon Monoxide (CO)	mg/m^3	4	BDL															
7	Ammonia (NH3)	µg/m^3	400	BDL				BDL	10.5	BDL	12.5	10.6	30.1	BDL	11.5	10.5	24.5	13.5	26.1

From the results presented in the table, it can be observed that the pollutant concentration at all locations was found to be lesser when compared to 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/m³ which is found to be way less than the standards. Maximum ozone concentration was observed for AAQ-8. At 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/m³. 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 VIII**.

3.4 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. As per CPCB guidelines 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 3-16. Figure 3-17 shows the sampling locations in the map.

Table 3-19 Noise Monitoring Results and Standards – September 2020

Locations	Description	Day Time (Leq)	Standards Day Time (Leq)	Night time (Leq)	Standards Night Time (Leq)
N-1	Industrial Area	44.9	75	36.4	70
N-2	Residential Area	47.2	55	38.4	45
N-3	Residential Area	38.0	55	33.9	45
N-4	Residential Area	40.5	55	34.0	45

N-5	Residential Area	54.8	55	43.0	45
N-6	Residential Area	43.3	55	35.3	45
N-7	Residential Area	50.7	55	39.3	45
N-8	Residential Area	46.8	55	35.6	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 3-19. It can be observed that the noise levels at all the monitoring locations within the study 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 IX**

Table 3-20 Noise Monitoring Results and Standards – October 2019

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 above. 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 IX**.

3.5 Marine Environment

3.5.1 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 3-21**.

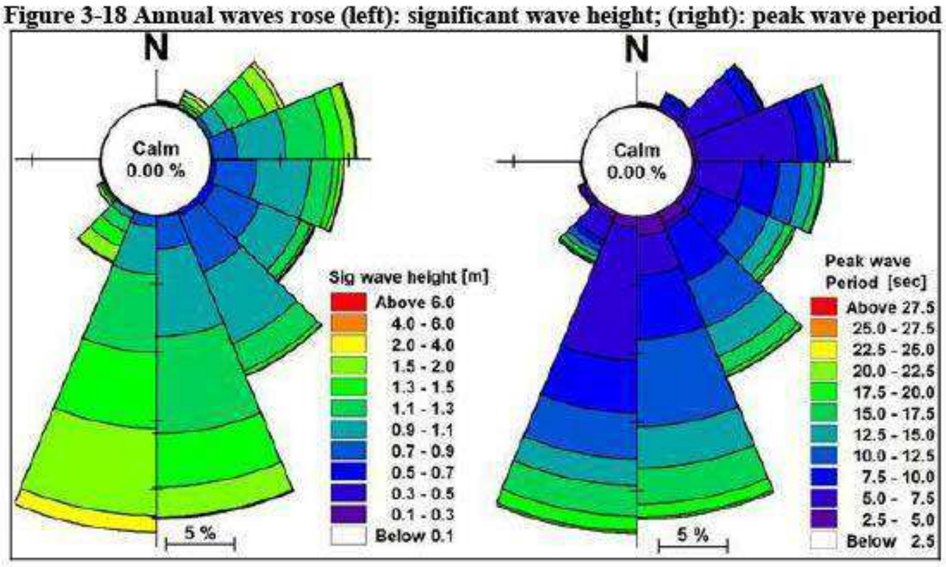
Table 3-21 Tide Level off Cuddalore Coast

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

3.5.2 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 3-18.

Figure 3-18 Annual waves rose (left): significant wave height; (right): peak wave period



3.5.3 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.

3.5.4 Bathymetry

Bathymetry data is assembled from Side mounted Echo sounder (Figure 3-19). Parts of the model domain outside the immediate project area use bathymetry from C-map. C-Map is a global digitised chart, which includes the water depth contours and water surface elevation data (tidal stations) for the entire globe. The various data sources were merged, aligned, gridded and quality controlled before proceeding for simulation. The overall bathymetry generated for the hydrodynamic simulations are shown in Figure 3-20.

Figure 3-19 Left - C-Map bathymetry; Right - Bathymetric data from Echo sounder

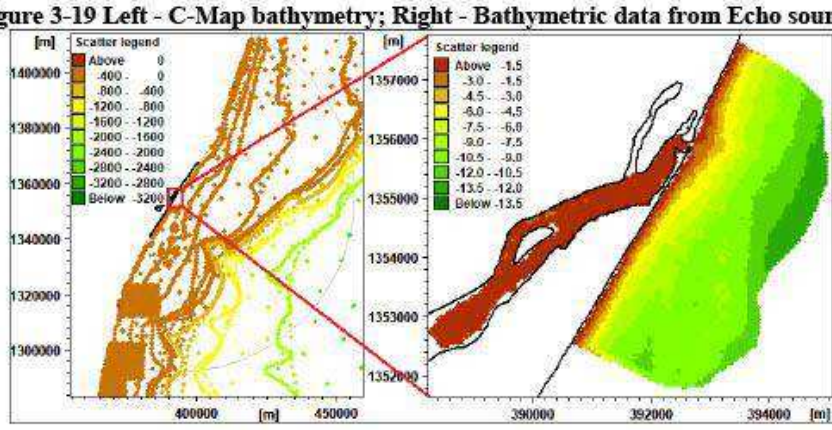
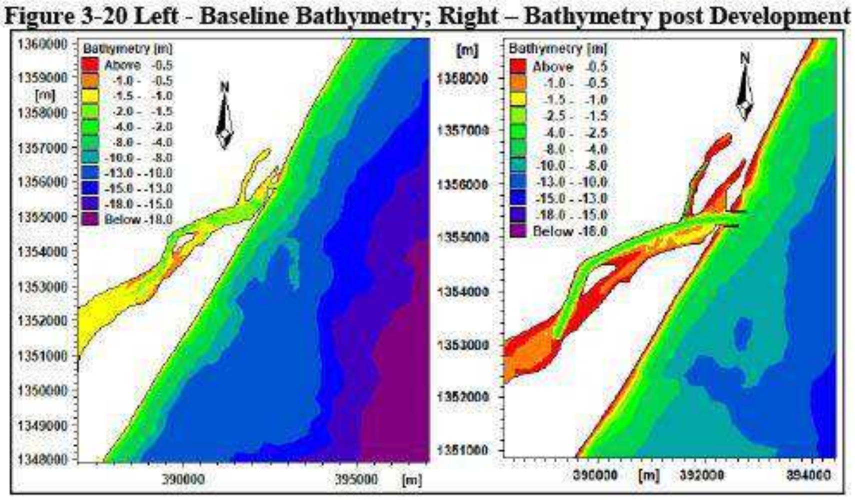


Figure 3-20 Left - Baseline Bathymetry; Right – Bathymetry post Development



3.5.5 Marine Water Quality

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 3-22 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 3-23** (Surface Water) and **Table 3-24** (Bottom Water). Google Earth imagery indicating marine water sampling stations are shown in Figure 3-21. 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 3-22.

Figure 3-21 Marine Water Sampling Locations

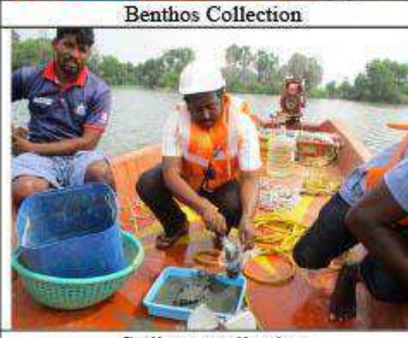
Figure 3-22 Marine water sampling within study area

Surface Water Collection	Bottom Water Collection

Phyto & Zoo plankton Collection

Benthos Collection

Sediment Collection



Sediment collection

Table 3-23 Results 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

3.5.5.1 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. 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 X**.

Table 3-24 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:10 0.0)	260	BDL(DL:10 0.0)	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

3.5.5.2 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. 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**

3.5.6 Marine Sediment Quality

Marine Sediments were collected in the same locations where a water sample was collected. The summary of marine sediment quality results are shown in Table 3-25..

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 3-22 Marine water sampling within study area. The test reports of the marine sediment are given in **Annexure XI.**

Table 3-25 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)

3.5.6.1 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.

3.6 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

3.6.1 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.

3.6.2 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.

3.6.3 Survey Methodology

3.6.3.1 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.

3.6.3.2 Equipment / Instruments deployed:

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

3.6.3.3 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.

3.6.3.4 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).

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

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

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

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

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

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

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.

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

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

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

3.6.4 Observations

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 lists 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.

3.6.5 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.

Table 3-26 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

S.No	Species Name	Family	Core (Zone I)		
			Frequency	Abundance	Density
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

3.6.5.1 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.

3.6.5.2 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.

3.6.5.3 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 stans, Calotropis gigantean, Ricinus communis, Lantana camera* and *Nerium oleander* were common along roadside. Shannon index value for this zone is

Table 3-27 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 occidentale*	Anacardiaceae	50.00	2.750	68.8
4	*Annona squamosa*	Annonaceae	62.50	1.400	35.0
5	*Artocarpus heterophyllus*	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 equisetifolia*	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 leptophylla*	Myrtaceae	37.50	1.333	33.3
17	*Ficus bengalensis*	Moraceae	25.00	1.000	25.0
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

S.No	Species Name	Family	Buffer Core - 2.5 KM (Zone II)		
			Frequency	Abundance	Density
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

3.6.5.4 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 3-28 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 occidentale*	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 equisetifolia*	Casuarinaceae	75.00	1.833	45.8
11	*Ceiba pentandra*	Malvaceae	37.50	1.000	25.0

S. No	Species Name	Family	Buffer Core - 5 KM (Zone III)		
			Frequency	Abundance	Density
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 leptophylla*	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
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

3.6.5.5 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 3-29 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 occidentale*	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 arundinacea*	Poaceae	20.00	1.000	25.0
9	*Borassus flabellifer*	Arecaceae	50.00	1.200	30.0
10	*Calophyllum inophyllum*	Calophyllaceae	20.00	1.000	25.0
11	*Cassia siamea*	Fabaceae	30.00	1.333	33.3
12	*Casuarina equisetifolia*	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
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 leptophylla*	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 hortensis*	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

S.No	Species Name	Family	Buffer Core - 10 KM (Zone IV)		
			Frequency	Abundance	Density
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 santalinus*	Fabaceae	10.00	3.000	75.0
41	*Roystonia regia (Royal*	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
52	*Ziziphus jujupa*	Rhamnaceae	20.00	1.000	25.0

Figure 3-23 Floral Species within Study Area

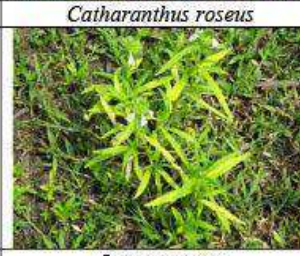
Acalypha indica

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*

3.6.6 Faunal Diversity

3.6.6.1 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 during construction period. 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 3-30 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
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

S. No	Scientific name	Common Name
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 3-24 Avifauna observed in study area during survey period

Ashy Crowned sparrow Lark

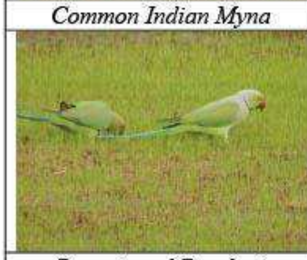
Black Drango

Black shouldered Kite

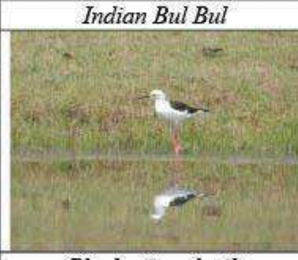
Common Indian Myna

Indian Bul Bul

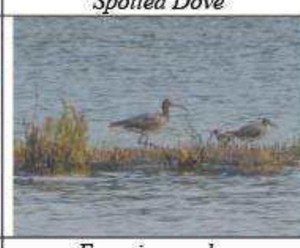
Spotted Dove



Rose ringed Parakeet



Black winged stilt



Eurasian curlew

		
Pied King fisher	Redwattled Lapwing	Northern Pin tail duck
		
Cattle egrett	*Temminick stint*	*Open billed stork*

3.6.6.2 Mammals and Reptiles

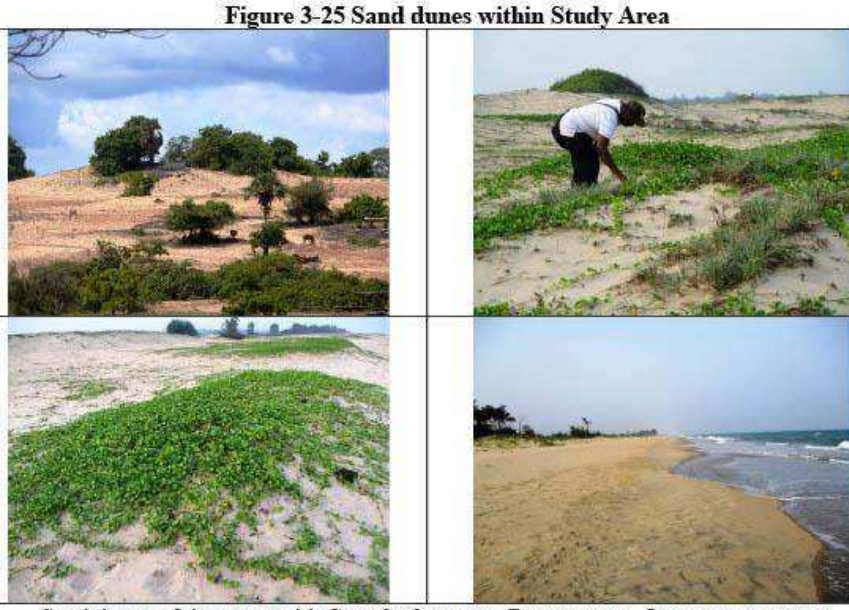
Villagers in the buffer area confirmed the presence of Indian Fox (Vulpes bengalensis), Wild Hare (Lepus nigricollis), and Grey Mongoose (Herpestes edwardsii). Other major reptiles are Cobra, Commom Krait, Vipers, Rat Snake, and Monitor Lizard.

3.6.7 Sand Dunes and Turtle Nesting Places within Study Area

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 phenomenon known as "**arribada**" (Spanish for arrival).

Figure 3-25 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*

3.6.8 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 identified in 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.*

3.6.9 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 3-26 Mangroves within Study Area

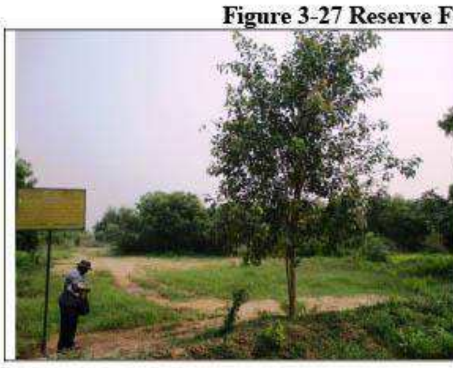
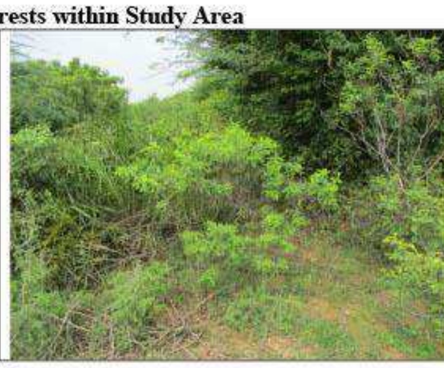

Avicennia intruded by *Prosopis juliflora* and inhabitant of *Rhizophora* among the *Avicennia* patches

3.6.10 Forest Blocks in Study Area

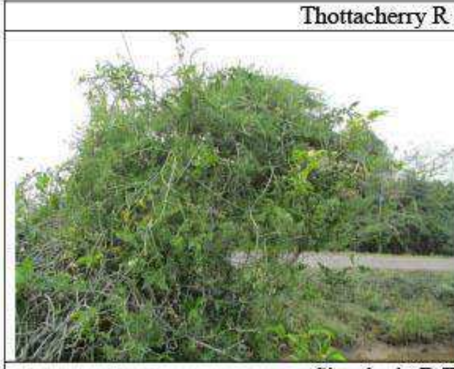
The forests represent peninsular mostly dry deciduous type of forest, mixed deciduous vegetation structure. There are three Reserve Forests in the study area Sittarkadu R F, Thottacherry R F and Agaram R F. The composition of Sittarkadu Reserve forest block mainly consist of shrubs species such as *Cassia 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*.

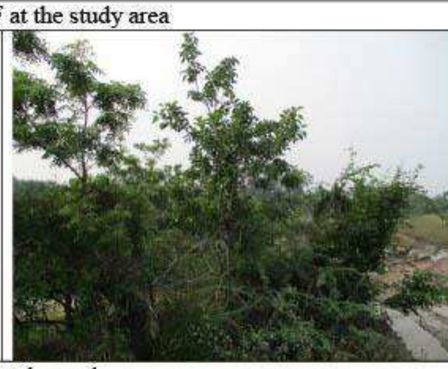
The composition of Thottacherry Reserve forest block mainly consist of shrubs species such as *Cassia auriculata, Lantana camera* and *Calotropis procera,* trees species such as *Ficus religiosa, Pithecelobium dulce, Acacia leucophloea, Pterocarpus marsupium* and *Borassus flabelliber*.

Figure 3-27 Reserve Forests within Study Area

Thottacherry R F at the study area





Sittarkadu R F at the study area

3.6.11 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.

3.6.11.1 Methodology

The marine monitoring for DHI project was conducted on 5th and 6^{h} 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 3-31**.

Table 3-31 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 3-28 Sampling of Marine Biotic Components

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

3.6.11.2 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.

3.6.11.3 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.

3.6.11.4 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.

3.6.12 Observations

3.6.12.1 Phytoplankton

Phytoplanktons recorded from the 8 locations of the project site are represented by 66 species among them 48 species belongs 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 3-32 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
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

S.No	Genera / Species	Stations							
		MS1	MS2	MS3	MS4	MS5	MS6	MS7	MS8
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
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

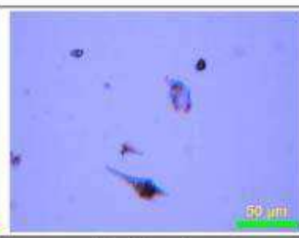
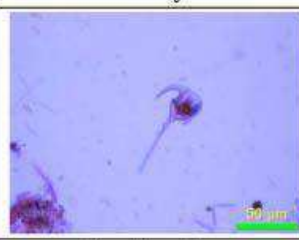
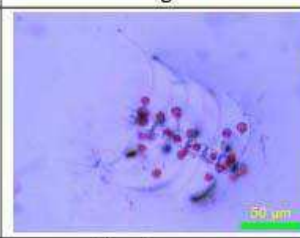
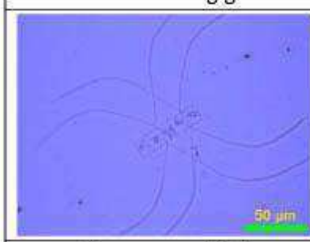
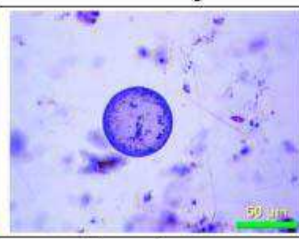
Phytoplankton community of study area showed wide variation in abundance though species richness remained more or less similar over entire study area **(Table 3-33)**. However, significant temporal variations were observed. Maximum number of species (39 nos.) was observed at station 4. Minimum number 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 3-33 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,*
6	24.3	37	*Coscinodiscus, Ceratium*
7	21.4	36	*Amphora, Pleurosigma*
8	19.4	35	*Amphora, Pleurosigma*

Figure 3-29 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.*

3.6.12.2 Zooplankton

Zooplankton community in the study area exhibited very diverse population and high abundance during November 2019 **(Table 3-34)**. 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 3-34 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 3-35**

Table 3-35 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 3-30 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

3.6.12.3 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;

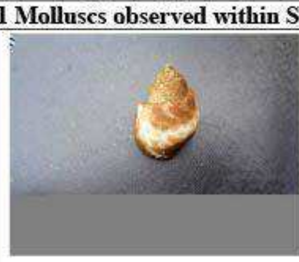
Nematodes > Foraminiferans > Ostracods > Bivalvia > Gastrapods > Polychaetes

Table 3-36 Distribution of Benthos in the study area

S. No	Group (Nos./m^2)	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

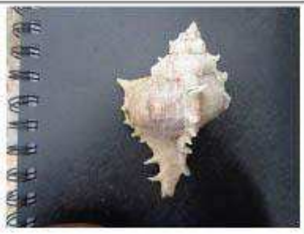
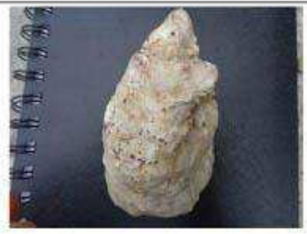
Figure 3-31 Molluscs observed within Study Area

Anadara sp



Babylonia spirata

Bullia vittata

		
Cardita sp	*Chicoreus virgineus*	*Crassostrea gigas*
		
Donax faba	Donax incrnatus	*Donax scortum*
		
Fusinus forceps	Glossaulax didyma	*Hemifusus cochlidium*

3.6.13 Statistical Analysis

3.6.13.1 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 3-37),** while that of zooplankton community is 1.246 **(Table 3-38).** 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 Index$\lambda = \sum n(n-1)/N(N-1)$

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 3-37 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 3-38 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**

3.6.14 Findings of Annamalai University

A detailed biodiversity impact assessment study and environment management plan has to be carried out through an Institute of repute on marine, brackish water and freshwater ecology and biodiversity for obtaining the environmental clearance for the proposed fishing harbours at Azhagankuppam and Alamparaikuppam. The Department of Fisheries, Government of Tamil

Nadu engaged the services of Centre of Advanced Study in Marine Biology, Annamalai University", a well reputed and pioneering marine institute having vast experience in assessment of coastal and marine biodiversity, for carrying out the above referred study. A team of experts from Annamalai University undertook the biodiversity study in the Kaluveli Estuary from 12.12.2020 to 13.12.2020 and the results area as detailed in the following subsection. The detailed report is attached as **Annexure XII**.

3.6.14.1 Pigments

In the present study, the chlorophyll '*a*' in water sample varied from 0.942 to 2.935 mg/m^3, with maximum at KBW-3 and minimum at KBW-11. The Phaeopigments content varied from 0.925 to 3.075 mg/m^3 with maximum was at KBW-3 and the minimum was observed at KBW-11. The Total biomass values varied from 1.102 to 3.419 ml/100m^3, with maximum at KBW-3 and minimum at KBW-11.

Table 3-39 Pigments recorded in Kaluveli backwaters

Station ID	Chlorophyll 'a' (mg/m3)	Phaeopigments (mg/m3)	Total biomass (ml/100m3)
KBW-1	2.004	2.430	2.612
KBW-2	2.178	2.182	2.428
KBW-3	2.935	3.075	3.419
KBW-4	2.119	2.752	2.896
KBW-5	1.385	1.985	2.022
KBW-6	1.627	1.859	2.147
KBW-7	2.119	2.284	2.539
KBW-8	1.850	2.446	2.675
KBW-9	1.631	1.936	2.028
KBW-10	1.624	2.045	2.145
KBW-11	0.942	0.925	1.102

Station ID	Chlorophyll 'a' (mg/m3)	Phaeopigments (mg/m3)	Total biomass (ml/100m3)
KBW-12	2.036	2.137	2.407

3.6.14.2 Phytoplankton

As many as 54 phytoplankton species belonging to thirteen groups namely Bacillariaceae, Naviculoideae, Bellerocheaceae, Biddulphoidae, Chaetocereae, Coscinodisceae, Eucampiinae, Asterionellaceae, Soleniceae, Triceratiinae, Ceratiaceae, Peridiniaceae, Prorocentraceae, Dinophysiaceae and Blue Green algae were recorded. Of these, Coscinodisceae were found to be the dominant group with 8 species. Chaetocereae and Naviculoideae formed next dominant groups with 6 species and Soleniceae with 5 species, Triceratiinae and Blue Green algae with 4 species each. Dinophysiaceae, Ceratiaceae and Bacillariaceae with 3 species each and Bellerocheaceae, Biddulphoidae, Eucampiinae, Asterionellaceae, Peridiniaceae and Prorocentraceae came last in the order with 2 species each.

Among the Coscinodisceae, *Coscinodiscus centralis, C. gigas, C. granii, C. radiates, Lauderia borealis* and *Skeletonema costatum* were found to be the commonly occurring species in the samples collected in various stations. In Chaetocereae, species such as *Bacteriastrum comosum, Chaetoceros affinis, C. currvisetus* and *C. diversus* were recorded commonly from the surveyed stations. Similarly, species such as *Bacillaria paradoxa, Leptocylindrus danicus, Rhizosolenia alata, Ditylum brightwelli, Odontella mobiliensis, O. sinensis, Anabaena* sp., *Trichodesmium* sp., *Microcystis* sp. and *Oscillatoria* sp.. in Soleniceae, Triceratiinae and Blue Green algae and *Nitzschia longissima, N. seriata, Bellerochea malleus, Biddulphia obtuse, Eucampia zoodiacus, Dinophysis puncata, D. caudate, Prorocentrum micans, Ceratium furca, C. macroceros* and *Astrionella glacialis* in Dinophysiaceae, Ceratiaceae, Bacillariaceae, Bellerocheaceae, Biddulphoidae, Eucampiinae, Asterionellaceae, Peridiniaceae and Prorocentraceae showed consistency in their occurrence in the samples collected in various surveyed stations.

The phytoplankton species diversity (H') varied from 2.894 to 3.867 with maximum value was recorded at KBW-2 and minimum at KBW-10. The species richness (d) ranged between 4.768 and 6.421 with maximum at KBW-12 and minimum value was recorded at KBW-1. The species evenness varied from 0.832 to 0.926 with the maximum value was recorded at KBW-3 and minimum at KBW-11.

Table 3-40 Biodiversity Indices of Phytoplankton

Station ID	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.364	4.768	0.919
KBW-2	3.867	5.918	0.904
KBW-3	3.816	5.560	0.926
KBW-4	3.174	5.363	0.901
KBW-5	3.026	4.830	0.832
KBW-6	3.162	5.495	0.877
KBW-7	3.426	5.188	0.901
KBW-8	2.918	5.171	0.862
KBW-9	3.352	4.864	0.892
KBW-10	2.894	4.979	0.851
KBW-11	2.946	4.981	0.832
KBW-12	2.963	6.421	0.836

3.6.14.3 Zooplankton

A total of 50 species belonging to 6 groups of macro zooplankton namely, Calanoid copepods, Cyclopoid copepods, Harpacticoid copepods, Ciliates, Rotatoria and Other Crustacean forms, and 5 groups of micro zooplankton namely, Mollusca, Larvacean, Pteropoda, Foraminifera and Annelida were recorded. In macro zooplankton, Calanoid copepod was found to be the dominant group with 14 species. Ciliates came as next dominant group with 8 species and Cyclopoid copepod with 7 species. Harpacticoid and Other Crustacean forms came next in the order with 5 species each. Among microzooplankton, Larvacean and Foraminifera were recorded with 3 species each and Mollusca, Rotatoria with 2 species each and Annelida and Pteropoda with 1 species each to the total zooplankton abundance.

Of the various taxa, the species namely *Eutintinnus tennuis, Favella brevism, F. philipiensis, Rhabdonella lohmani, Tintinnopsis tocantinensis, T. tubulosa, T. butzschi, Acartia centrura, A. danae, Acrocalanus gibber, Paracalanus parvus, Pseudodiaptomus aurivilli, Temora tubinata* and *Tortanuus barbatus* were found to be common during this survey. Similarly Bivalve veliger, Gastropod veliger, *Globigernia bulloides, G opima* and Polychaete larvae among micro zooplankton, showed consistency in their occurrence in the samples collected in various stations. As done for phytoplankton, the zooplankton species diversity (H') varied from 2.528 to 3.736 with maximum in KBW-2 and minimum in KBW-9. The species richness (d) ranged between 4.639 and 6.683 with maximum in KBW-6 and minimum in KBW-3. The species evenness varied from 0.764 to 0.927 with the maximum in KBW-2 and minimum in KBW-10.

Table 3-41 Biodiversity Indices of Zooplankton

Station ID	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.510	5.258	0.834
KBW-2	3.736	4.739	0.927
KBW-3	3.384	4.639	0.895
KBW-4	3.288	4.925	0.884
KBW-5	3.492	5.017	0.821
KBW-6	3.110	6.683	0.816
KBW-7	2.899	5.641	0.897
KBW-8	2.703	6.419	0.807
KBW-9	2.528	5.652	0.784
KBW-10	2.793	5.013	0.764
KBW-11	2.604	5.335	0.838
KBW-12	2.785	5.977	0.809

3.6.14.4 Macro-Benthos

Five groups of benthic organisms namely polychaetes, bivalves, gastropods, amphipods and group "others" were recorded in Kaluveli backwaters. Among them, polychaetes constituted the dominant group followed by bivalves, gastropods, amphipods and group 'others'. Altogether, 37 species of macro fauna were recorded from surveyed stations. Of these, polychaetes topped the list with 21 species. Bivalves were found to be the next dominant group in the order of abundance with 9 species. Gastropods and group "others" came next in the order with 4 and 2 species respectively of the total benthic organisms collected. Amphipod came last in the order with one species during the present study.

Among the polychaetes, *Cossura coasta, Ancistrosyllis parva, Nephtys* sp., *N. capensis, Dendronereis* sp., *Nereis* sp. and *Notomastus* sp. were found to be the most commonly occurring species in the samples collected in Kazhuveli backwaters. Coming to bivalves, *Sunnata meroe, Meretrix Casta, Mactra laevis* and gastropods, *Cerithidea cingulata, Natica macrochiensis* and in group "others" crab, fish fry were found to be common species in the present survey respectively.

The macrobenthos species diversity (H') varied from 2.47 to 3.83 with maximum in KBW-2 and minimum in KBW-12. The species richness (d) ranged between 4.46 and 6.82 with maximum in KBW-12 and minimum in KBW-2. The species evenness varied from 0.81 to 0.97 with the maximum in KBW-2 and minimum in KBW-12.

Table 3-42 Biodiversity Indices of Macro-Benthos

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.32	5.63	0.90
KBW-2	3.83	4.65	0.97
KBW-3	2.69	5.40	0.83
KBW-4	2.65	5.04	0.88
KBW-5	3.09	4.46	0.86
KBW-6	3.18	4.59	0.92
KBW-7	3.54	4.95	0.93
KBW-8	2.75	6.03	0.92

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-9	3.45	4.71	0.91
KBW-10	3.03	4.87	0.96
KBW-11	2.32	6.82	0.88
KBW-12	2.47	6.34	0.81

3.6.14.5 Meio-Benthos

In the present study, as many as 44 species belonging to four groups of Meio-benthic organisms namely Foraminiferans, Nematodes, Ostracods and Harpacticoids were recorded. Among them, Foraminiferans topped the list with 26 species. Nematodes and Ostracods were found to be the next dominant groups in the order of abundance with 7 species each and Harpacticoids came next with 4 species.

Among the foraminiferans, *Ammodiscus exsertus, Ammonia beccarii, Bolivina punctuate, Elphidium advenum, Globigerina globularis, Quinqueloculina debenayi, Rosalina globularis, S. tuberculata, S. angulosa, S. bradyi* and *Trichohyalus aguayoi* were found commonly in various stations. With respect to nematodes, *Halalaimus filum, Oxystomina clavicauda, Enoplolaimus abnormis,* and *Neocamacolaimus parasiticus* were found to be the common species in the samples collected in various stations. The Ostracods species such as *Basslerites liebaui, Bairdoppilata scaura, Paracytherideis* sp., *Eucythere argus, Microcytherura nigrescens* and *Tanella gracilis* and the Harpacticoids, *Leptastacus mocronyx* and *Canuella perplexa* were found to be common species in the surveyed stations.

The Meio-benthos species diversity (H') varied from 2.735 to 3.621 with maximum was in KBW-2 and minimum in KWB-11 and similarly the species richness (d) ranged between 4.867 and 6.635 with maximum in KBW-6 and minimum in KWB-9. The species evenness varied from 0.741 to 0.912 with the maximum in KWB-2 and minimum in KWB-10

Table 3-43 Biodiversity Indices of Meio-Benthos

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	2.794	5.839	0.907

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-2	3.621	5.461	0.912
KBW-3	3.050	5.317	0.847
KBW-4	3.102	5.406	0.829
KBW-5	3.113	5.249	0.896
KBW-6	3.175	6.635	0.820
KBW-7	2.917	5.724	0.784
KBW-8	2.886	6.532	0.771
KBW-9	3.076	4.867	0.814
KBW-10	2.928	5.392	0.753
KBW-11	2.735	5.467	0.780
KBW-12	2.786	5.784	0.796

3.7 Socio-Economy

3.7.1 Study Area

The proposed fishing harbor is to be developed in the Kaluvali waters which lie in SFNo-23/1, Azhagankuppam village in Marakkanam taluk of Viluppuram district. The proposed project 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 2 Administrative divisions which include one revenue village, one 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 3-44** shows the administrative structure of the study area.

Table 3-44 Administrative structure of the study area

S.No	State	District	Taluk	Administrative Status	Name
1	Tamil Nadu	Villupuram	Tindivanam	Town Panchayat	Marakkanam
2				Revenue Village	Kandadu

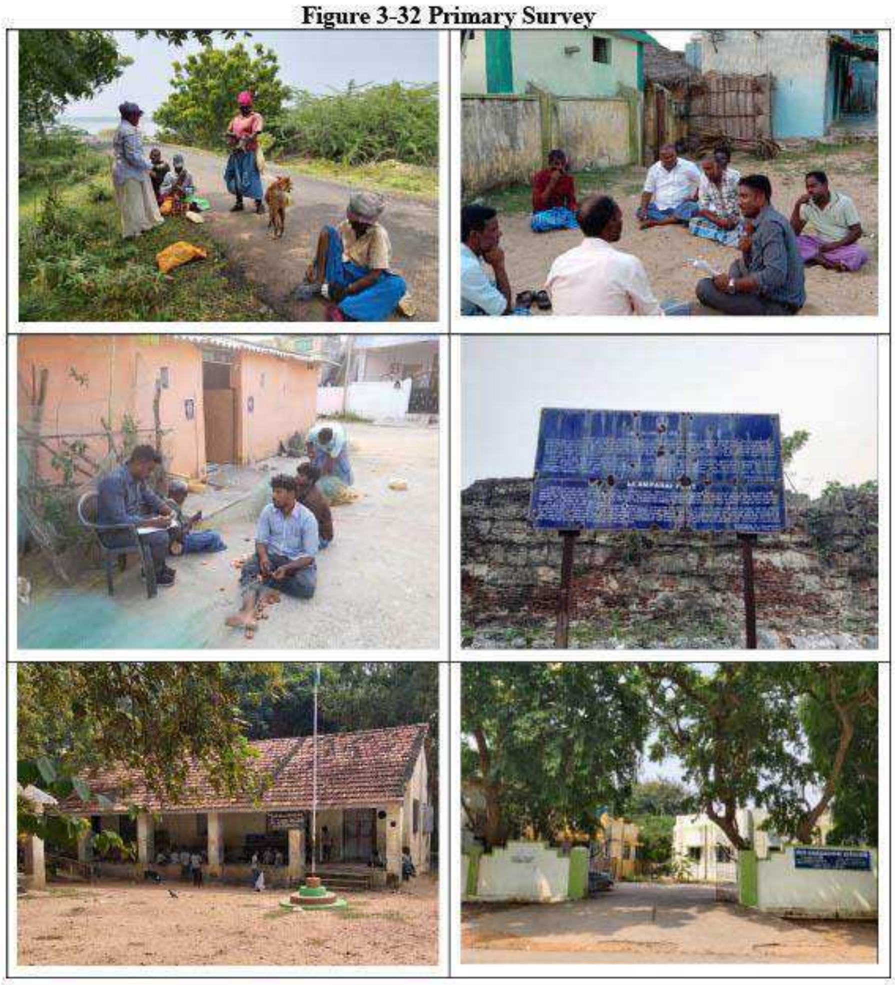
3.7.2 Socioeconomic Indicators Considered

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.

3.7.3 Primary Survey

Primary Survey was undertaken from5th to 8th November 2019 (**Figure 3-32**). 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 3-32 Primary Survey



3.7.4 Socioeconomic Profile of Study Area

3.7.4.1 Demography and Culture

The proposed fishing harbor is to be developed along the Kaluveli waters in SFNo-23/1, Azhagankuppam village , Marakkanam taluk of Viluppuram district 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 46,386males and 47,070 females. The children population below 6 years old was found to be 10,051which wasat10.75% 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.

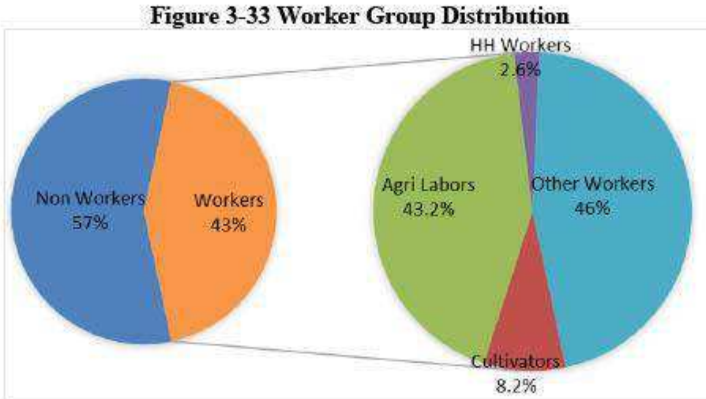
3.7.4.2 Livelihood and Economic Activity

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 3-33**).

Figure 3-33 Worker Group Distribution



Source: PCA, Census 2011.

3.7.4.3 Education Indicators

In the study area about76.6% 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 present study has been undertaken for the proposed fishing harbours that is to be developed over an area of 3.23ha at Azhagankuppam and 3.42ha at Alamparaikuppam by reclaiming over the intertidal area utilizing the dredge spoil generated from the dredging of the navigation channel and the navigation basin in Kaluveli Estuary. The environmental baseline conditions that were studied and described in the previous chapter were assessed for their impacts that they would incur due to the proposed development and operation of the fishing harbour. The impacts have been assessed for both terrestrial and marine environments. The environmental parameters have been selected for the identification, prediction and quantification of impacts based on the proposed activities and developments. The key environmental components identified for the environmental impact assessment are as follows:

- Physico-chemical Components – Surface and Ground water quality, Air quality, Noise quality, Soil quality & Land Use, Marine Water & Sediment Quality
- Ecological Components – Floral communities, Faunal communities, Terrestrial ecosystem and marine ecosystem.
- Socio-economic environment – Aesthetic conditions, public services, demography, socio-economic activities, employment potential.

The proposed project consists of construction of fish handling & storage facilities, associated infrastructure such as administrative building, ice plant on land and marine infrastructure such as development of training wall, diaphragm wall, navigation basin, waterfront etc. The construction activities are likely to cause more impacts on the marine environment than on the terrestrial environment as the proposed developments are on the intertidal area of the Kaluveli Estuary. This chapter details on the anticipated impacts on the terrestrial and marine environment during the construction and operation phase of the project. The qualitative and quantitative approaches have been undertaken to determine the impacts and mitigation measures have been suggested as per the EIA manual for Ports & Harbours published by MoEF&CC

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,

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

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 Land Environment

The proposed fishing harbor at Azhagankuppam will be developed over an area of 3.23ha within a land area of 5 ha, and the one proposed at Alamparaikuppam will be developed over an area of

3.42ha within a land area of 6 ha, both of which are registered in the name of Fisheries Department, which is designated by Government of Tamil Nadu (GoT) for Fisheries Department. Apart from the said land, no additional land will be required for developmental activities. The proposed fishing harbor will be developed by reclaiming the existing intertidal area which is currently occupied by salt affected land. The land area proposed for fishing harbor development is uninhabited and therefore, no R&R is involved. Besides, the proposed projects does not involve any diversion of Forest Land.

4.3.1 Impact during Construction Phase

The impacts on the land environment observed during construction phase are due to construction of supporting infrastructure 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 equipments 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 equipments 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.

4.3.2 Impact during Operation Phase

The major source of impact on land environment during operation phase will be due to solid waste. The generated solid and hazardous wastes shall be collected in the proposed soil waste collection point and disposed according to "Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016". Wastes such as used oil, discarded containers and STP sludge are envisaged. Those wastes shall be collected and will be disposed through authorized vendors.

4.4 Air Environment

4.4.1 Impact during Construction Phase

The possible impacts that would arise from the construction phase to the air environment are explained below, which are expected to be short term and restricted to construction phase.

Site Preparation: The project site will be prepared for the harbour development by clearance of site of any vegetation and grading. The site clearance, grading/leveling, reclamation and soil compaction will be taken up before undertaking the construction activities. Fugitive dust emissions are expected during dry weather conditions from the site clearance and leveling operations, but would of temporary nature and hence the impact due to this activity is considered to be low.

Vehicular Movement and Construction Equipment: The vehicular movement of men and materials and the operation of construction equipment would generate emissions of SO_2, NO_2 and CO due to combustion of fuel. However, this activity is restricted to construction phase (temporary) and will not overlap with the emissions during the operational phase of the harbour.

Also, the raw materials transported by trucks may possibly cause dispersion of airborne particles and may affect the air in the adjoining communities/communities enroute if they are not covered during transportation. Hence, all the construction materials will have to be covered during transportation to avoid this impact.

Mitigation Measure: Although the above stated impacts on the air environment is temporary, adopting good management practice would enable in reducing those temporary impacts. Measures such as water sprinkling shall be adopted on roads and construction area to control dispersion of dust. Well maintained and serviced construction equipment's should be used at site for effective and environment friendly operation. Further, employing well trained skilled workers for operation of machinery and deployment of vehicles complying with the BS VI Emission Norms would reduce the fugitive emissions from vehicles and machinery.

4.4.2 Impact during Operation Phase

The major sources of air pollution during the operation phase of the proposed fishing harbours include point source from fishing vessel emissions and line source from vehicular emissions. The major air pollutants from the abovementioned sources include Sulphur-di-Oxide (SO_2) and Nitrogen-di-Oxide (NO_x) from vehicular emissions and fishing vessel emissions whereas, Particulate Matter ($PM_{10\&2.5}$) as fugitive dust emissions from vehicular movement. Apart from these, vehicles emit Carbon Monoxide (CO) and Hydrocarbon (HC) which are also considered for the model study. In order to predict the incremental concentration of pollutants in the air environment due to the proposed project during the operational phase, air quality modelling study has been undertaken.

4.4.2.1 Air Quality Modeling

The primary objective of the air quality modeling study is to predict the most likely possible ground level concentrations due to combined emissions from all possible sources in the study area. USEPA developed Gaussian plume dispersion models such as ISCST3 and AERMOD are recommended by MOEF&CC for impact identification. Figure 4-1 depicts the overview of the methodology adopted for conducting air quality modeling and impact prediction. The peak 24 hours average background ambient air concentrations were considered (Baseline data of July 2020 to September 2020) to estimate cumulative impact on air quality in the study area. The modeled peak predicted Ground Level Concentrations (GLCs) were added with respective baseline concentration considering the distance and direction. The results were then compared with the NAAQS for identifying the cumulative impacts in the study area.

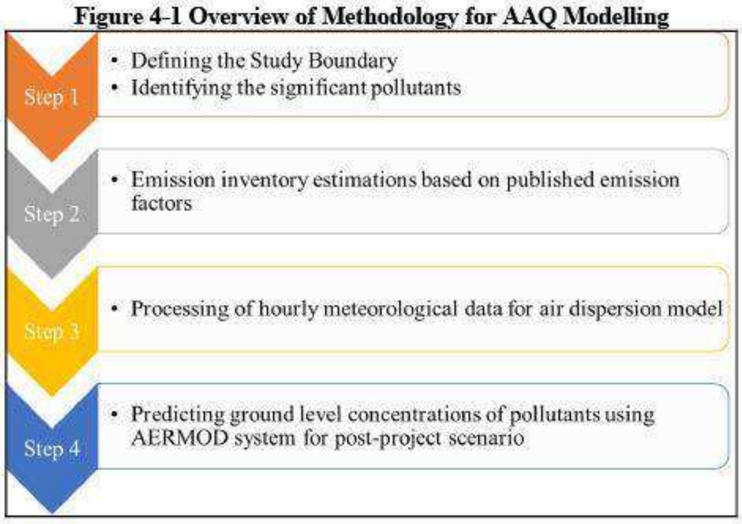
Prediction of impacts on air environment has been carried out by employing mathematical model based on a steady state Gaussian Plume Dispersion Model designed for multiple point sources for short term. In the present case, AERMOD dispersion model, designed for multiple point sources for short term and approved by United States Environmental Protection Agency [USEPA] and MoEF&CC has been used for simulations.

The pre-processors of the AERMOD are:

1. AERMAP- This feature is used to map out the terrain elevation. Since the proposed area of development is a flat terrain, AERMAP was not used for processing.

2. AERMET- upper air data obtained from processing the site-specific meteorological data collected during the primary survey period from July 2020 to September 2020.

Figure 4-1 Overview of Methodology for AAQ Modelling

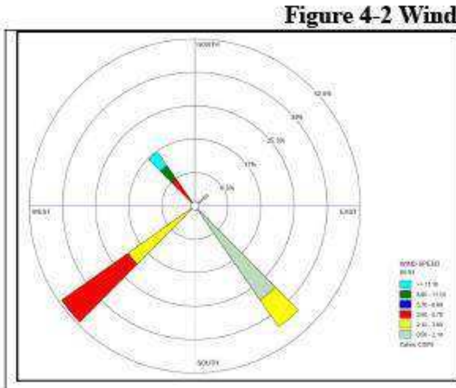


4.4.2.2 Factors Affecting Pollutant Dispersion in the Atmosphere

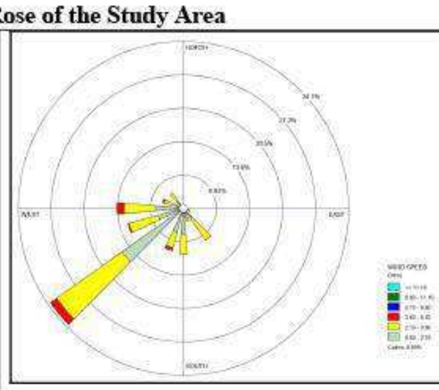
Local and regional Geographical Features: The terrain type with varying wind patterns and speeds will have an impact on the pollutants dispersed in the atmosphere. In the current scenario, the study area is a estuarine and plain coastal land. The area depicts a typical rural background.

Meteorological Conditions: The meteorological conditions considered for the modelling are wind speeds, wind direction, solar insolation and mixing height. The windrose for the study area is represented in **Figure 4-2**.

Figure 4-2 Wind Rose of the Study Area



IMD Data
(July – September)



Primary Baseline Meteorological Data
(July 2020-March 2020)

4.4.2.3 Basic Assumptions

The air model has been carried out for the total fishing handling capacity of 12000 TPA that will be handled at each of the proposed fishing harbours. The impact was assessed for the worst-case scenario considering the following scenarios.

- The maximum cargo capacity for the fishing habour was considered for maximum possible quantity (which is non-realistic during normal operation).
- The mechanized fishing vessel engine capacity was considered as 120 kW.
- The fishing habrour was considered to have operational days of 200 days.
- The number of fishing vessels have been identified based on the maximum possible number of boats to be present within the Kaluveli Estuary at an instance from both Alamparaikuppam and Azhagankuppam with 4 mechanized boats and 10 motorized boats from each of the proposed harbours.
- It has been assumed based on the fish catch transportation from the harbor that 70% of the catch will be evacuated by 9 tonne carriage capacity trucks and 30% by 0.71 tonne carriage capacity vehicles through road.

4.4.2.4 Model Inputs

For predicting the impacts on air environment due to the proposed developments the following emission sources have been considered in the modelling study;

- Point Source: Fishing vessel emissions
- Line Source: Vehicular emissions

Vehicular Emissions

The vehicular traffic movement in and around the port carrying cargo has been considered as ***line source*** of emissions. These vehicles are usually heavy diesel engine trucks. The emission factors for these types of vehicles are considered as per the data provided by Central Pollution Control Board (CPCB) and Automotive Research Associate of India (ARAI)[8].

Fishing Vessel Emissions:

The point sources identified near the harbor during its operation phase are the chimneys or stacks from the mechanized vessels and the on board engines from small fishing boats.

4.4.2.5 Background Air Quality in the Study Area

To assess the background ambient air quality of the study area, ambient air quality monitoring stations were setup at 5 locations around the project site. Air quality was monitored from December 2018 to March 2019. (Winter Season). The 24-hour averaged ambient air quality of all the monitoring sites are given in **Table 4-1**.

Table 4-1 24 Hour averaged baseline ambient air quality

	Unit	AAQ1	AAQ2	AAQ3	AAQ4	AAQ5	AAQ6	AAQ7	AAQ8
PM	$\mu g/m^3$	40.1	44.7	35.8	53.4	65.4	34.8	60.1	68.5
SO_X	$\mu g/m^3$	5.8	3	3	5.8	9.6	3	9.2	12.6
NO_X	$\mu g/m^3$	13.1	9.7	6.7	12.7	20.4	4.8	18.5	28.7

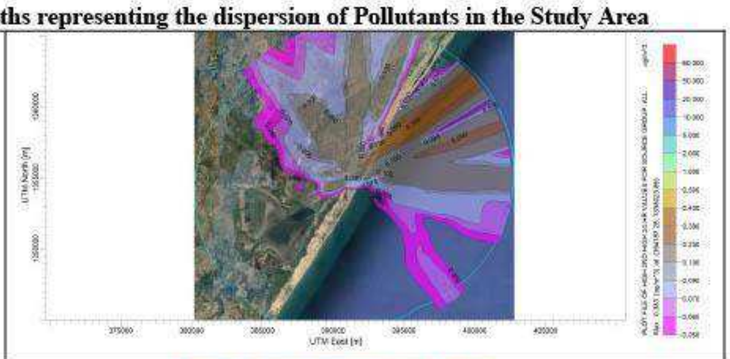
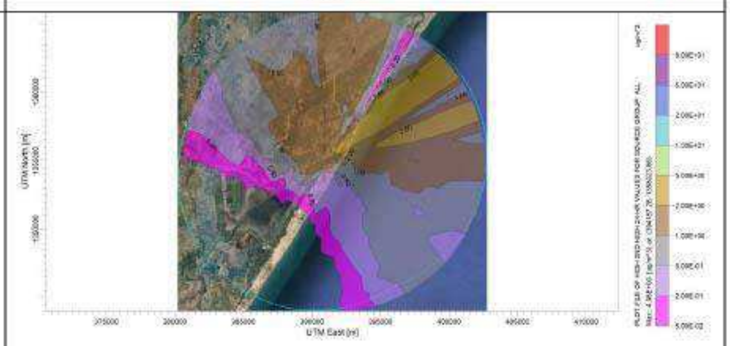
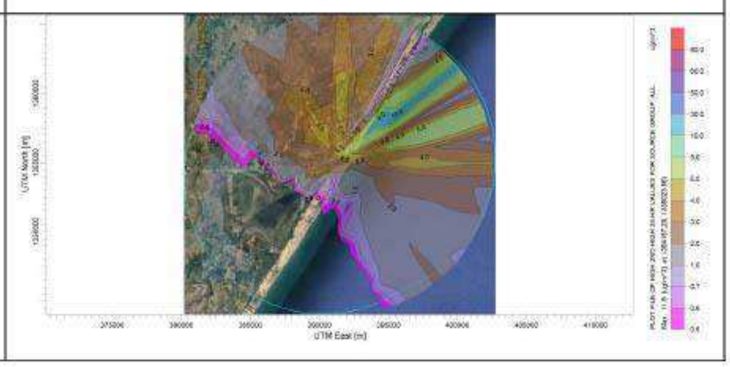
4.4.2.6 Results and Discussions

The air quality modelling study was carried out using the inputs considered for the worst-case

[8] Vehicular emission norms by CPCB: http://cpcb.nic.in/vehicular-exhaust/

scenario and the 2nd highest Ground Level Concentrations (GLCs) of the criteria air pollutants have been presented in **Figure 4-3**.

Figure 4-3 Isopleths representing the dispersion of Pollutants in the Study Area

Particulate Matter	
Oxides of Sulphur (SO_x)	
Oxides of Nitrogen (NO_x)	

The summary of the resultant concentrations at the baseline locations are represented in **Table 4-2**.

Table 4-2 Summary of results of air quality modelling

	PM (µg/m³)			SO (µg/m³)			NO (µg/m³)		
	Baseline	**Increment**	**Cumulative GLC**	**Baseline**	**Increment**	**Cumulative GLC**	**Baseline**	**Increment**	**Cumulative GLC**
AAQ1	40.1	0.16	40.26	5.8	2.17	7.97	13.1	5.16	18.26
AAQ2	44.7	0.02	44.72	3	0.32	3.32	9.7	0.76	10.46
AAQ3	35.8	0.1	35.9	3	1.29	4.42	6.7	3.08	9.78
AAQ4	53.4	0.11	53.51	5.8	1.42	7.22	12.7	3.39	16.09
AAQ5	65.4	0	65.4	9.6	0.04	9.64	20.4	0.09	20.49
AAQ6	34.8	0.02	34.82	3	0.28	3.28	4.8	0.68	5.48
AAQ7	60.1	0	60.1	9.2	0.03	9.23	18.5	0.06	18.56
AAQ8	68.5	0.12	68.62	12.6	1.57	14.17	28.7	3.76	32.46

4.4.2.7 Impacts as predicted from Air Quality Modeling

Based on the findings of the air quality modeling, it has been inferred that all the resultant cumulative concentrations in the post-project scenario within the 10 km radius of the study area is found to comply with the NAAQ standards. The predicted maximum concentrations at the within the Kaluveli Estuary due to the fishing vessels and the movement of trucks for the transport of the catch were found to give lesser increments on the land and over the estuary / sea environment. The incremental concentrations are very low which when combined with the baseline concentrations were found not exceeding the standard limits.

Mitigation Measures: The impacts on the quality of air can be controlled, if not prevented, by enforcing certain good management practices within the harbor and in the Kaluveli Estuary by limiting the number of vehicles entering the harbor as well as the number of vessels leaving / entering the estuary.

4.5 Noise Environment

The noise levels in the environment are likely to increase due to the proposed activities. The air emissions will disperse in the environment for a certain distance before it settles down. However, the noise emissions will increase and affect the local region and gets dissipated over distance. Noise emissions are recognized as one of the regulated parameters under Environment Protection Act, 1986, hence the contribution of noise pollution due to the proposed development has been predicted using the scientific models.

4.1.1 Impact during Construction Phase

Sources: The anticipated sources of noise and vibration during construction phase of the proposed project are vehicles transporting men and materials, diesel engines of construction machinery and dredgers, pile driving activities during construction of the harbour, construction equipment & machineries, and mechanical & construction works during site clearance, preparation & construction activities. The construction equipment includes excavators, generators, concrete conveyors, drilling, pile driving equipment etc. The trucks that carry raw materials to the facilities for construction could contribute to the stress in the noise environment.

Impacts: The noise generated from these sources will affect the fauna in the region. Due to the operation of dredgers, and diesel engines during construction, the resulting noise and vibration will cause migration of faunal species away from the core zone of impact to safer grounds. Moreover, the associated alteration in water environment due to vibration will result in migration of aquatic organisms, as well, till the end of the period of construction. The construction activity would also affect the habitation near the proposed project site, especially at Alamparaikuppam. The vibration of heavy machinery will also cause disturbance to the workers in the region. The duration of the impacts will be of short term and the effects on the environment are reversible.

Mitigation Measures: The noise during the construction phase of the fishing harbours may cause disturbance to humans or animals, therefore mitigation measures shall be undertaken in the best interest of the people and the workers at site. To limit any heath effect in workers at site during the construction phase, ear muffs shall be provided to workers deployed to operate in and near heavy machinery. Also, the construction equipment shall be regularly maintained for proper functioning and control of noise. The vehicles that would be deployed should comply with the BS-VI Emission Norms. The construction activities should be limited to day time, and no activity shall be undertaken during night time.

4.1.2 Impact during Operation Phase

Sources: The major contributions to the increase in noise and vibration in the study area during the operation phase are: vehicular movement on internal and external roads and fishing vessel movement, and operation of DG sets (at times of power outages).

Impacts: The impacts due to noise during operation phase are associated with the movement of vehicles and fishing vessels and boats. Hence, a noise modeling study was undertaken to predict the noise during the operation of the fishing harbours.

According to the environmental regulations, industrial facilities should adopt sound noise abatement and control program to meet the prescribed noise emission criteria. The regulation on noise standards are prescribed in the "The Noise Pollution (Regulation and Control) Rules 2000" under the "Environmental Protection Act, 1986". As per the requirement, the day time and the night time noise levels in the industrial area (that is located outside the boundary of the industry) shall not exceed 75 and 70 dB(A) Leq respectively. The periodicity considered as daytime lasts from 6 am to 10 pm and the nighttime lasts from 10 pm to 6 am. The ambient noise standards are presented in the Table 4-3. Noise levels near the work-zone areas should comply with a maximum permissible level of 85 dB (A).

Table 4-3 Ambient Air Quality Standards in respect of Noise

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

4.1.2.1 Noise Modeling Study

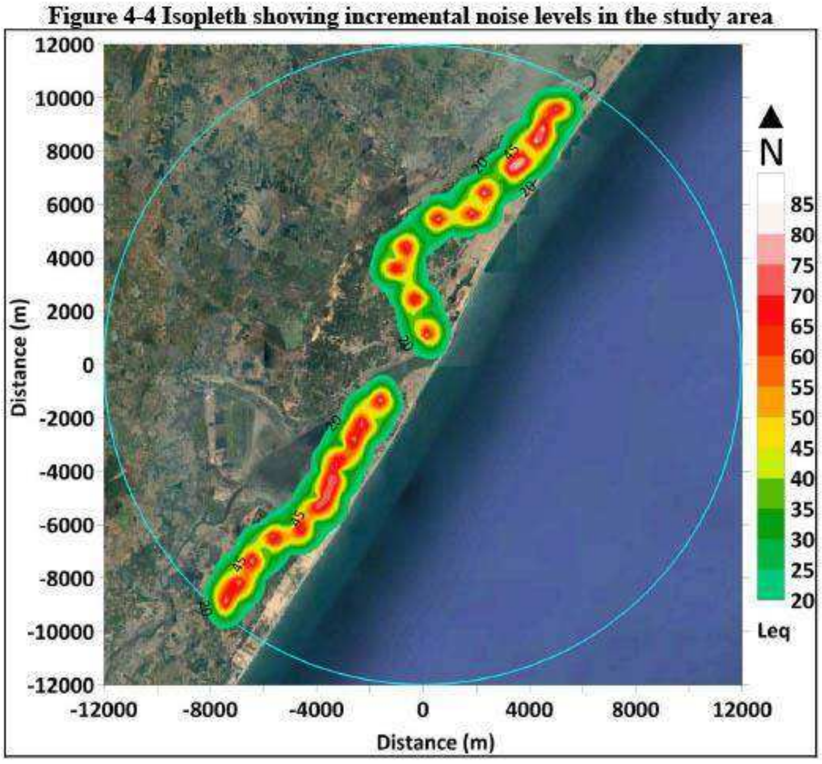
As a part of this EIA study, a noise propagation modeling was undertaken to establish the abated noise levels at the proposed port boundary. The noise emissions from various identified potential sources were modeled based on the ISO outdoor noise propagation standards.

- ISO 9613-1:1996 Acoustics- attenuation of sound during propagation outdoors- Part 1: Calculation of the absorption of sound by the atmosphere
- ISO 9613-2:1996 Acoustics- attenuation of sound during propagation outdoors- Part 2: General method of calculation

Noise propagation software model, Noise Sim Version 2.1 has been used for estimating the sound pressure levels due to dispersion of noise emissions from the designated sources. The primary inputs required for the model are the noise power levels from the respective source (Lw-dBA), co-ordinates of the noise emission source, environmental parameters such as relative humidity, ambient temperature and wind speed. Noise model was undertaken for both the harbours proposed to assess the noise emission and its zone of impact.

Predicted sound pressure levels in around the proposed fishing harbours due to their operation are presented in **Figure 4-4**. It can be inferred from the model that the increment in sound pressure levels at the proposed harbour will be less than or equal to 75 dB (A), which is well within the stipulated threshold noise level of 75 dB (A) for industrial areas. From the noise modelling analysis, it has been concluded that, the predicted noise emission levels from the proposed fishing harbours will be well within the noise standards prescribed by the CPCB. Green belt proposed within the harbours is also expected to dampen noise level further. Also, the noise due to the trucks from the evacuation road was found to be dissipate within few meters from the source.

Figure 4-4 Isopleth showing incremental noise levels in the study area



Mitigation Measures: Although, the noise levels are predicted to be within the stipulated standards within the port, noise abating measures in order to provide a safe working zone for the fishermen who are deployed near the noise source. The major source of noise is from the ice plant and the movement of trucks to and from the harbours. To achieve low noise emission from the locomotives, the speed of the vehicles within the harbour and near habitations shall be kept under 20km/hr. Other than the vehicular source, noise is envisaged from the DG Sets that would be installed as a source of back-up power within the fishing harbours at various operational areas. To arrest the noise from DG sets acoustic enclosures shall be provided, in addition to mufflers for DG sets should be provided.

4.6 Traffic

The fish catch will be brought to the harbour in the wee hours of the day and be transported to the nearby local markets and to the ports for export by 8:00 AM. The early transport of the fish catch from the harbour would not cause any hindrance to the local traffic. It was estimated that 4 HMV and 34 LMV would be used for the transport of fish catch from each harbours considering 12,000 TPA and 200 operational days at either harbours. Also, the proposed fishing harbour will have internal road of width 10 m to avoid traffic congestion at the harbour entrance. Based on the IRC 106-1990 code the overall increase in commercial traffic envisaged during the working hours of proposed fishing harbours is only ~ 19 PCU (passenger car unit) where as the capacity of existing road network is 1200 PCU. The analyzed road network's carrying capacity indicates that the roads will be able to handle the additional traffic envisaged due to the proposed fishing harbours with no hinderance to overall traffic as the increase in commercial vehicle movement is minimal.

4.7 Soil Environment

The proposed project has developmental activities majorly on the intertidal environment and the impacts on terrestrial soil environment would be comparatively low. However, the impacts may arise due to runoff from construction activities and reclamation. The runoff from the construction activities may trickle down into the soil if it is stagnant for a long time. The reclamation involves deposition of the dredged materials on the intertidal region and hence there is no impact on the soils of the terrestrial environment. As the proposed development entirely falls on the intertidal area by way of reclamation, the process of reclamation would not affect the quality of soil in the upland. But due to the reclamation with dredged material, the level raising and compaction could have an impact in terms of percolation of saline water into the soil which may have eventually affect the groundwater.

Mitigation Measure: The dredge spoil that would be utilized for reclamation should be checked for suitability for use. In order to avoid the influence of salinity, the material shall be treated by gypsum that would leach the salt content in the soil. This would keep the quality of the groundwater unaffected by the dredge spoil to be used for reclamation.

4.8 Water Environment

The fishing harbours are proposed on the intertidal area rather than on the terrestrial side. This section details on the impact on the freshwater resources within the study area. The terrestrial water environment refers to the groundwater and the surface water. There are very few freshwater sources within the study area.

4.1.3 Impact during Construction Phase

The water requirement for the proposed project during the construction phase will be sourced through the tankers. There will no withdrawal of groundwater during the construction phase of the harbours. Also, there would not be any direct drawl of surface water by the fisheries department for the purpose of construction. The waters to be sourced by tankers will be ensured that they are drawn from approved sources. Hence there is no major impact on the groundwater or surface water (freshwater resource) due to the proposed project.

Mitigation Measure: Since the proposed project is to be developed on the reclaimed land, provisions for storm water drainage and the wastewater drains should be developed in the construction phase of the project to limit runoff from site. The stagnation of contaminated water (runoff from construction activities) over a period of time has the possibility of penetrating into the groundwater since the groundwater table is at shallow depth in the intertidal region where the development is proposed. Therefore, proper draining of stagnant water at site should be made.

4.1.4 Impact during Operation Phase

The proposed harbours will utilize about 25KL of water for its daily operation. This requirement would be met by water sourced by tankers. As mentioned earlier, the storm water drains and the wastewater drains will be constructed for the proposed project. No discharge of wastewater into the nearby water bodies is envisaged and will be contained within the harbour facility. The wastewater drains will collect the wastewater from the open areas, storage areas, roads, auction halls, auction halls, etc. There is no discharge of wastewater into the nearby water bodies and will be contained within the facility. The sewage generated from various facilities within the harbour and the wastewater collected in the drain will be directed to and treated in the 15 KLD STP that is proposed. The treated wastewater will be used for greenbelt and other non-potable purposes within the harbour. Hence there is no discharge of untreated wastewater into the environment.

4.9 Marine Environment

The Marine environment encompassed within the study area is sub-divided into two categories namely tidal influenced Kaluveli Estuary and the coastal area based on their location. The impacts on marine environment have been identified though qualitative approach while their degree of intensity have been quantified thorough various numerical models that area presented in the following sections.

4.9.1 Impact during Construction Phase

As part of the proposed fishing harbour development various infrastructures will be developed and majorly in the marine environment such as training wall, diaphragm wall, navigational channel, navigation basin and other associated facilities/ infrastructure. Dredging and land reclamation for development of the harbours and navigational facilities is a major component of the proposed development. Prior to the assessment of impacts due to various project components the hydrodynamic parameters such as tides, currents, wind, etc. of the area were assessed and are presented in the Baseline chapter under marine environment which will be a base to the subsequent study.

4.9.1.1 Impact due to Dredging

For the development of the two fishing harbours and construction of two training walls, a total of 1.2 M.Cum of dredge spoil will be generated. 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. During dredging mixing of minerals from waterfront area (kaluveli estuary and Bay of Bengal) with marine water will alter the chemical composition of the waters. The footprint area where construction is proposed will suffer permanent loss of benthic species. Bentonite used during pilling will contaminate the water column. However, 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.

4.9.1.2 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 of 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 4-4 & Table 4-5 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 4-6 & Figure 4-7.

Table 4-4 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 4-5 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 4-5 Modeled Current Speed for baseline conditions

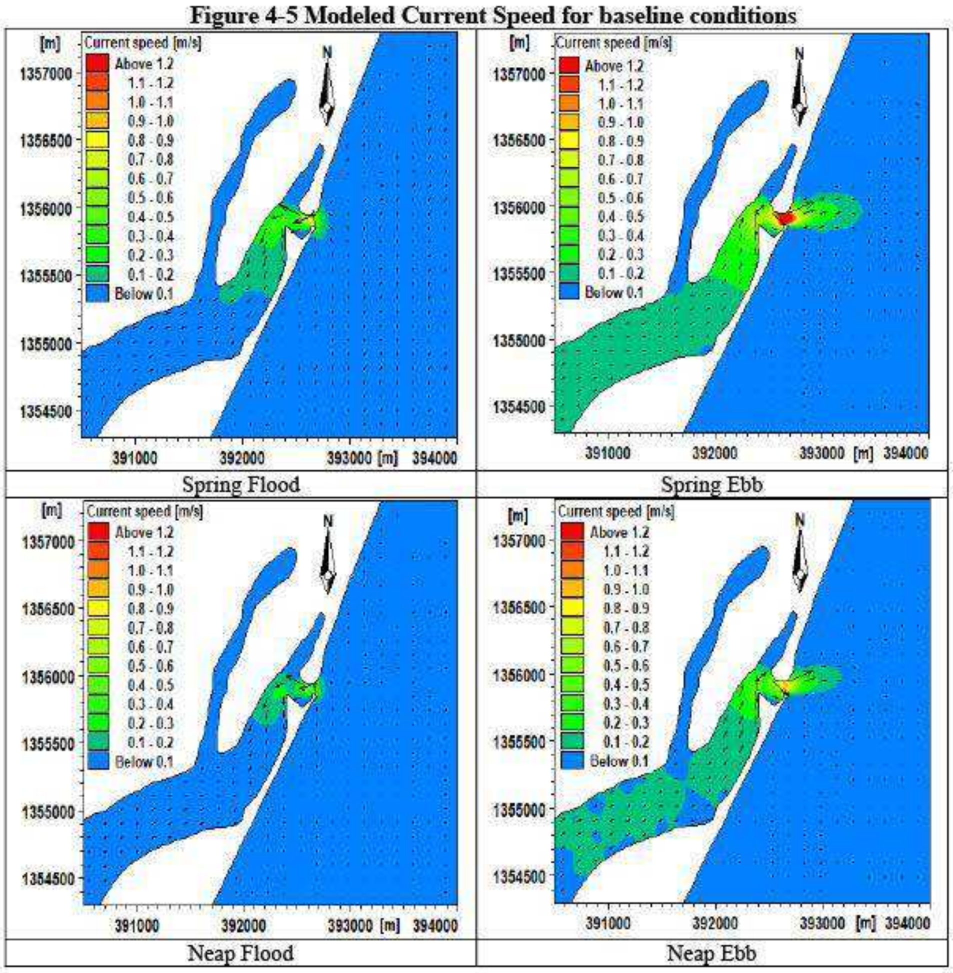
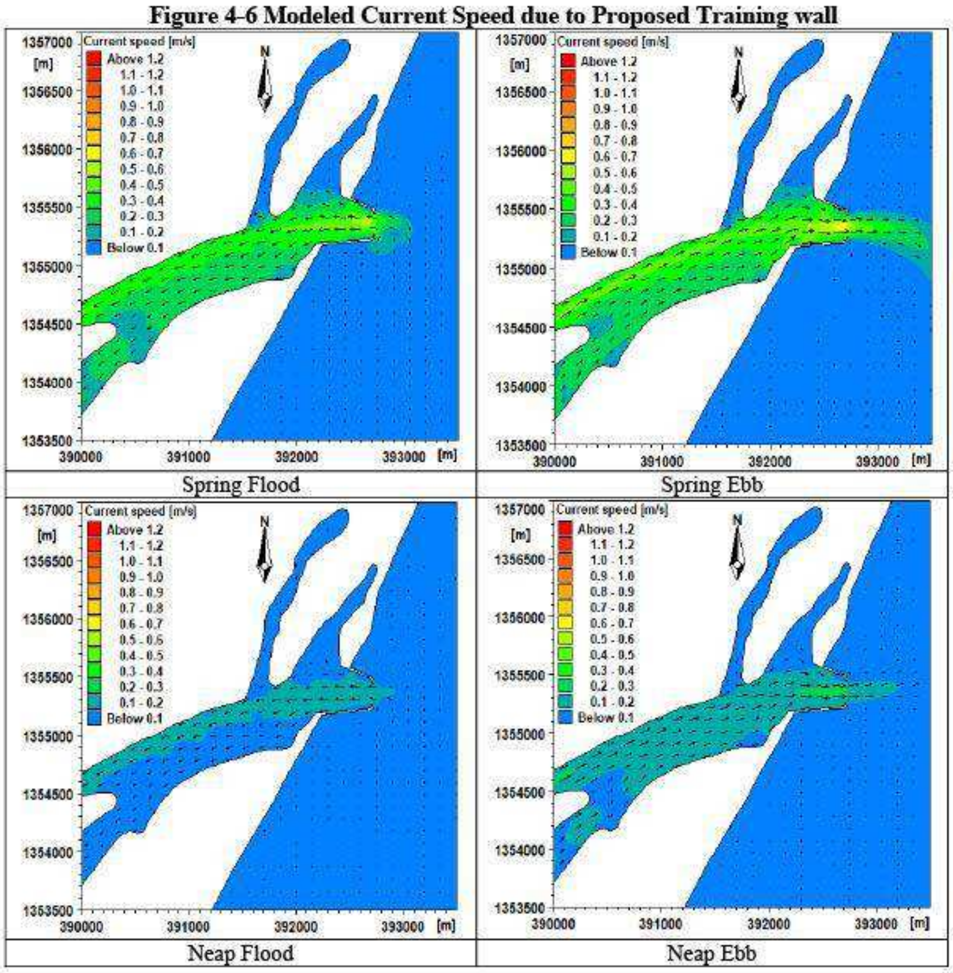


Figure 4-6 Modeled Current Speed due to Proposed Training wall



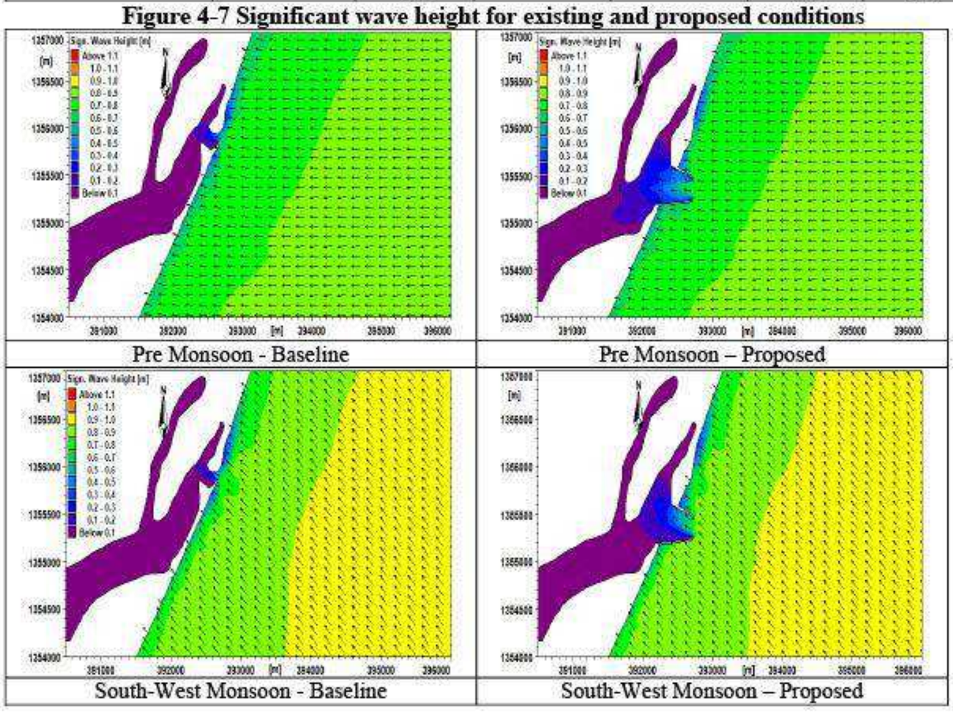
4.9.1.3 Impact on Tranquility

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 4-6 and the spatial variation is shown in Figure 4-7.

Table 4-6 Significant wave height for existing and proposed conditions

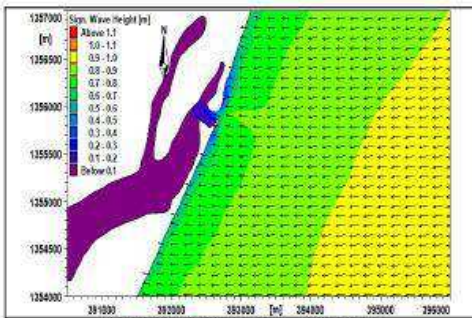
Location	Significant Wave Height (Baseline)			Significant Wave Height (Propsoed Developments)		
	Pre-Monsoon (m)	SE Monsoon (m)	NE Monsoon (m)	Pre-Monsoon (m)	SE Monsson (m)	NE Monsoon (m)
Harbor Entrance	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5	0.4-0.5
Berthing	Below 0.1	Below 0.1	Below 0.1	Below 0.1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

Figure 4-7 Significant wave height for existing and proposed conditions

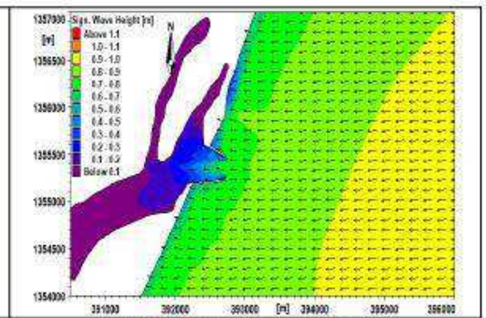


Pre Monsoon - Baseline | Pre Monsoon – Proposed

South-West Monsoon - Baseline | South-West Monsoon – Proposed



North-East Monsoon - Baseline



North-East Monsoon – Proposed

4.9.1.4 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 **Table 4-7**. 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:

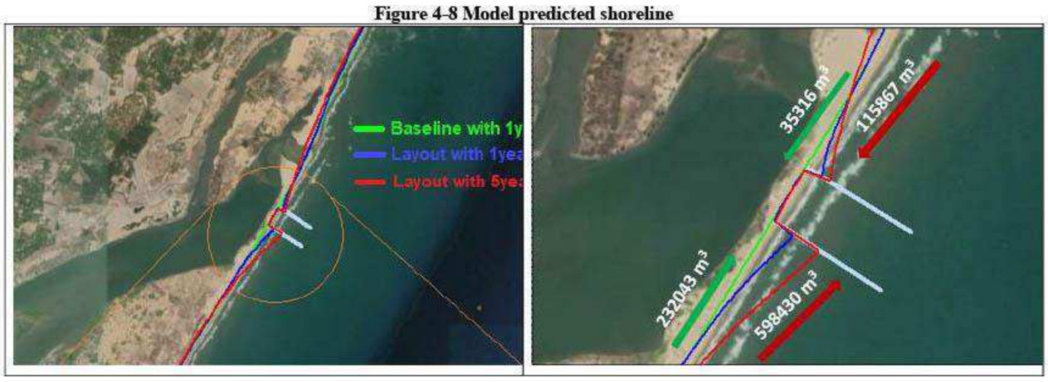
- Northward movement of sand in the order of 2,32,043 m^3 and southward movement of sand in the order of 35,316 m^3 is noticed with the baseline conditions for 1 year.
- Northward movement of sand in the order of 1,56,482 m^3 and southward movement of sand in the order of 49,419 m^3 is noticed with the 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 4-7.

Table 4-7 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 4-8 Model predicted shoreline



Mitigation Measure: The excess dredge spoil 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.

4.9.2 Impact during Operation Phase

Wash water from the boat deck can carry contaminants along with them 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. No discharge of wastewater is proposed during the operation phase.

During maintenance dredging, suspended sediment concentration is expected to increase which will increase the turbidity 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.

4.9.2.1 Impact due to Oil Spill

A stochastic oil spill assessment is undertaken to assist with oil spill contingency planning for the proposed fishing harbour at Azhagankuppam in Villupuram District and Alamparaikuppam in Chengalpattu District in Kaluveli Waters. The spill events were assessed for each of the fishing harbours to evaluate potential oil spill impact to the surrounding environmental resources.

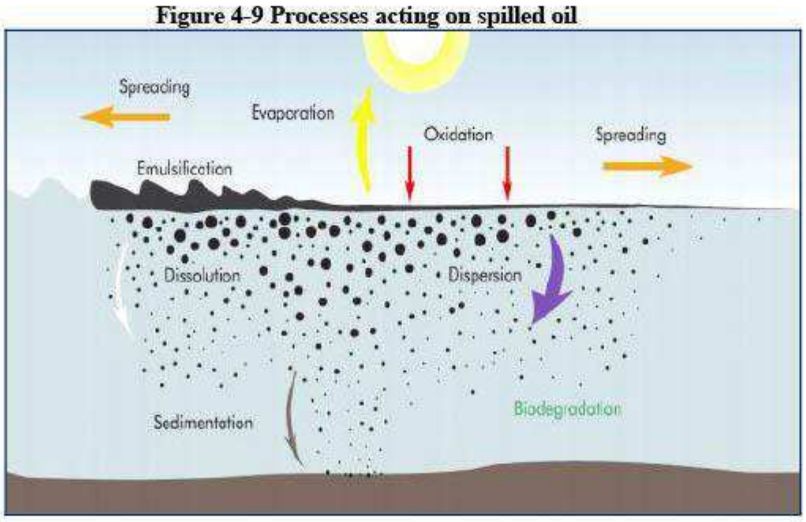
Oil Spill Modeling

The simulation of the hydrocarbon spills has been carried out using DHI's Oil Spill model MIKE 21 OS. In this model the oil is represented as (Lagrangian) particles being advected with the surrounding water body and exposed to weathering processes. The advection (drift) of the individual particles is determined by the combined effects of current, wind and bed drag. The model provides information on oil slick locations, the amount of oil left on the sea surface, the slick mobility and the evolution of the physiochemical properties of the oil. The weathering processes included in the model are described below.

Oil Spill Process

MIKE 21 OS model describes the spreading and weathering of oil spills in an aquatic environment under the influence of water movements and the associated dispersion processes. The oil itself is defined according to its distillation properties and chemical structure. The processes are considered in the models includes spreading, evaporation, emulsification, vertical dispersion, and dissolution.

Figure 4-9 Processes acting on spilled oil



The physical and chemical changes that spilled oil undergoes are collectively known as weathering. Although the individual processes causing these changes may act simultaneously, their relative importance vary with time. Together they affect the behaviour of the oil and determine the fate.

Oil Spill Scenario

A single surface spill scenario is defined in terms of the spill location, oil properties, rate, duration, and temperature. The oil is divided into five fractions, each characterized by a vapour pressure, water solubility, viscosity, and density. An oil spill of 2 tonne at each fishing harbour due to collision of mechanized fishing vessels (trawlers) was considered and modeled.

Results

The analysis of trajectory and arrival time of spilled oil indicates the oil being confined to the

Kaluveli Estuary. Analysis of simulated result indicates the plume being confined to the estuary and not spreading to the open sea or upstream into the Kaluveli wetland which inhabits mangroves and other aquatic organisms. The extent of the spillage and the time of the arrival of the spill from Alamparaikuppam Fishing harbour and its trajectory is provided in the Figure 4-10 and Figure 4-11.

Figure 4-10 Extent and thickness of oil spill from Alamparaikuppam

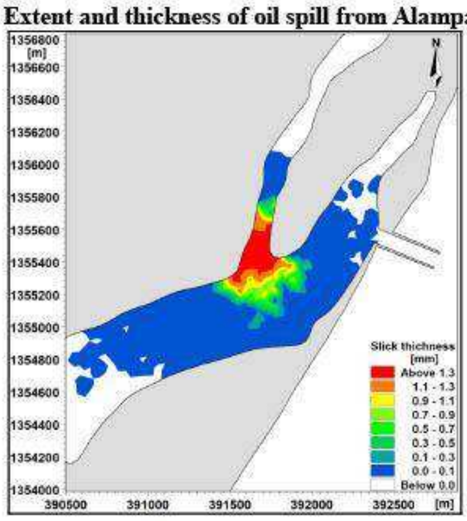
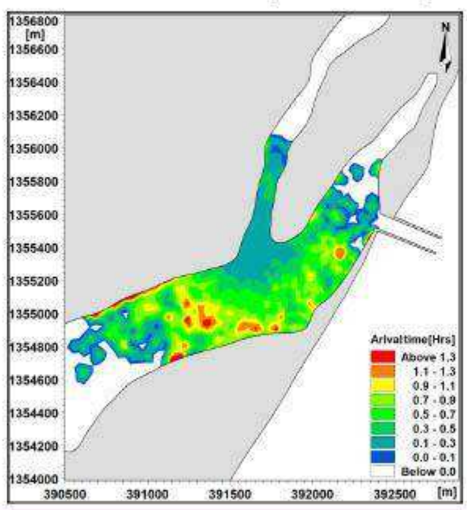


Figure 4-11 Time of arrival of the spill from Alamparaikuppam



The extent of the spillage and the time of the arrival of the spill from Azhagankuppam Fishing Harbour and its trajectory is provided in the Figure 4-12 and Figure 4-13.

Figure 4-12 Extent and thickness of oil spill from Azhagankuppam

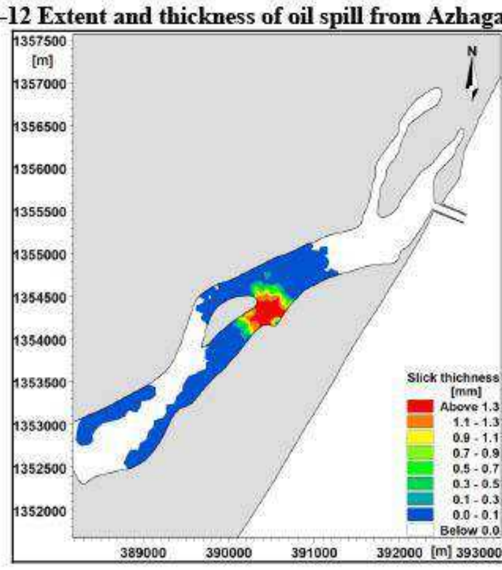
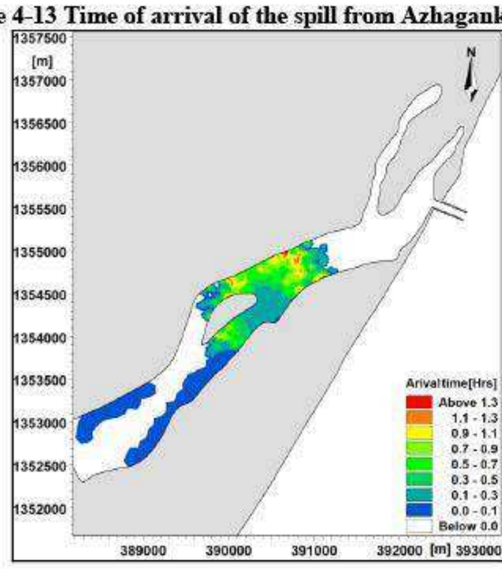


Figure 4-13 Time of arrival of the spill from Azhagankuppam



4.10 Ecological Environment

4.10.1 Impact during Construction Phase

The proposed fishing harbour does not involve any diversion of forest area or protected areas. Therefore, no impact is envisaged on the forest lands within the study area. Also, the land in which the harbours are to be developed are intertidal areas that is devoid of any agriculture or aquaculture practices. Hence, the proposed project would not cause any hinderance to any agriculture or aquaculture that is in practice in the region. As the proposed fishing harbours at Azhagankuppam and Alamparaikuppam, is a greenfield project, there would be a significant impact on the ecological set up of the area, for being the fact they are proposed in the Kaluveli Estuary. As the proposed site at Alamparaikuppam inhabits scattered mangrove vegetation of about 1m in height, the significance of impact is high. The clearing of site in the pre-construction phase would lead to loss of mangroves. Kaluveli wetland is a biologically diverse and rich water body inhabiting aquatic flora and fauna, and as well as serving as a nursery and feeding ground for the marine organisms and avifaunal species. Therefore, the dredging that is proposed would affect the turbidity in the water column which will eventually affect the population and density of the primary producers and consumers and other aquatic lives. Also, the dredging activity would cause loss of the benthic habitat; however, recolonization of benthic organisms can be witnessed over a period of time. The noise generated from the construction equipments could disturb the aquatic as well as terrestrial fauna which would migrate to safer grounds. The construction of training wall as part of the proposed project would lead to improved and increased fluctuation of tidal reach which would improve the survival and growth of mangrove species in the upstream of Kaluveli Estuary and also establishment of new colonies of marine species within the Kaluveli Estuary.

4.10.2 Impact during Operation Phase

Possible discharges from the fishing vessels and boats such as bilge water, oily waste, oil leakage from vessels, lubricants could be source of water pollution. Oil spillages form a sleek film layer on the water surface toxic to the planktonic population. Besides, any discharge or spillage from the vessels may cause direct damage to the fishery resources, aquatic biota and coastal habitat.

Indirect damages to bottom biota and habitat may also be caused. Water pollution and bottom contamination resulting from these discharges could potentially lead to deterioration of aquatic biota and fishery resources.

Although maintenance dredging is proposed only when required, it may tend to cause damage to marine biota due to:

- Re-suspension and settlement of sediment leads to smothering on benthic community
- Raise in turbidity, thereby decreasing the light penetration and primary productivity
- Sudden fall in dissolved oxygen levels
- Alterations in species compositions and structure of benthic communities
- Disturbances and loss of benthic habitat
- Reduction in bottom biota which is usually linked to a losses in fishery resources

Major construction and maintenance dredging activities in the intertidal and sub tidal areas proposed for the development of the harbours will influence the local ecology and impact on the intertidal biota, loss of bottom habitat, phytoplankton, zooplankton and benthic organism. As kaluveli wetland that is located 5km upstream of the proposed fishing habours is observed as an important bird area as it attracts migratory birds in the post monsoon season. However, the development of the harbours and its operation would not have a significant impact on the migratory birds as the villages bordering the Kaluveli Waters are already involved in deep sea and estuarine fishing using motorized boats. The fishing harbour development can see an increase in the avifaunal population as it is observed is various harbours along the coasts of India and across the globe.

Mitigation Measures: Major impact envisaged on the ecology of the project area and the Kaluveli Estuary is during capital dredging. Therefore, it is advised to avoid dredging activity during the fish breeding season as well as during the turtle nesting season. To control / minimize the effect of turbidity on the aquatic flora and fauna in the vicinity of dredging, isolation of activity by installation of silt screens / curtains is recommended. Efforts to trap run-off slurry and sediment plume from the dredging area by means of silt traps is to be ensured and the trapped sediments is to be responsibly disposed in pre-designated sites.

Measures to ameliorate the impact like reducing the sediment load through changes in operational procedure (such as appropriately timing the operation in tune with tides and tidal current direction) may be considered. Areas of material fabrication during construction will be adequately spaced from intertidal area that its impacts are not felt on the waters of Kaluveli. It is equally important that construction related activities near intertidal zone are confined within the smallest area possible which will reduce the construction related impacts on the coastal waters.

The opening of the Kaluveli estuary mouth would improve the tidal fluctuation and the extent of reach, which will improve the diversity of marine aquatic species as well as their density within the Kaluveli waters. The improved tidal fluctuation would also improve support and enhance the growth of mangroves and its associated flora and fauna.

4.11 Socio-Economic Environment

4.11.1 Livelihood Enhancement

Viluppuram and Chengalpattu 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.

4.11.2 Increase in the regional economy

Due to non-availability of the fishing harbors 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, etc. in the nearby vicinity which will improve the economic status of the region and also promotes foreign exchange through exports.

4.11.3 Traffic

The proposed fishing harbor is located in Azhagankuppam and Alamparaikuppam village which is adjacent to and connected by East Coast road which is prone to road accidents. Due to the proposed fishing harbors 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.

5.2 Alamparaikuppam

5.2.1 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 5-1 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 5-1 Site Selection Matrix – Azhagankuppam and Alamparaikuppam

Aspects	Attributes	Azhagankuppam		Alamparaikuppam		
		Location 1	Location 2	Location 1	Location 2	Location 3
Environmental	Forest Land	5	5	5	5	5
	Ecologically Sensitive Area	2	3	4	3	4
	Breeding site	3	4	4	4	4
	Tree Cutting	2	4	5	2	2
Social	Connectivity	4	4	1	5	5
	Access to fishing villages	4	5	2	4	5
	R&R	4	5	1	5	5
Economical	Approach	3	5	5	2	4
	Dredging	3	5	3	2	2
	Capital Cost	2	5	3	2	2
	Maintenance Cost	2	5	3	4	4
		34	**50**	36	38	**42**

*Higher the score better the feasibility

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**.

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 Tamil Nadu.
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								
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 m^3	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

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

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
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

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
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	Maintenance	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

7 ADDITIONAL STUDIES

Apart from the sections discussed in EIA report, few additional studies have been carried out and are discussed in this chapter. The additional studies include Coastal Regulation Zone Study, concerns and Solutions put forward during Public Hearing, Disaster Management Plan and Risk Assessment.

7.1 Public Hearing

The proposed project is a greenfield project classified as Category B under the EIA Notification 2006. In compliance to the procedure for obtaining the environmental clearance and as per the Terms of Reference (ToR) accorded by the State Level Environment Impact Assessment Authority on 17th October 2020 vide Letter No. SEIAA-TN/F.No.7709/SEAC/7(e)/ToR-791/2020; Standard ToR point no. XXVII (27.), a Public Hearing is to be undertaken and the outcome of the same should be detailed in the EIA Report.

7.1.1 Azhagankuppam

The Public Hearing for proposed Fishing Harbour at Azhagankuppam Village was conducted on 12.01.2021 at MJR Thirumana Mandapam, No. 131, Pondy Road, Marakkanam Post & Taluk, Villupuram Dist. (8km from the proposed project site) and the summary of views / concerns raised during the public hearing is presented below:

A total of 99 public had attended the meeting chaired by Mr. A. Annadurai, I.A.S – Villupuram District Collector, Ms. Shreya P. Singh, I.A.S, - Villupuram District Additional Collector, Dr. S. Anu, I.A.S – Sub-Collector, Tindivanam, Villupuram District and Mr. S. Palanisamy – DEE, TNPCB, Villupuram. The advertisement for Public Hearing were published in English and Tamil daily newspapers on 10.12.2020.

A total of 14 views/concerns were raised by public during the event and all welcomed the project considering its benefits to the people and requested for timely completion of the project; the summary of the same is presented in **Table 7-1.**

Table 7-1 – Summary of Views/ Concerns of Public Hearing at Azhagankuppam Village Villupuram District

S.No	View / Concerns	Response
1.	The project was welcomed as it would improve the livelihood of the people and also lessens their dependence on Pondicherry fishing harbour	The project would enhance the livelihood of the people of the fishing village of Azhagankuppam by reducing the extra expenses that were spent on their travel to Pondicherry harbour from their village and the supporting facilities of the fishing harbour such as auction hall, ice plant, cold storage room, etc will expand their market and income.
2.	The project would prevent the clashes between the fishing communities of nearby villages.	The project would facilitate the dependent villages to form their management committee to govern the activities at the harbour and result in corporative harmony.
3.	The project will be the first fishing harbour in the district and help the fishermen in terms of protection against cyclones and other disasters	The project will act as a refuge for fishermen with small and large boats during cyclones and other similar disasters and bring down the fishermen dependency on neighboring fishing harbours such as Pudhucherry in an unlikely event.
4.	The project should provide employment to the educated persons belong to all the 19 villages in the proposed fishing harbour project.	The proposed project would provide employment to the people from the 19 villages in various capacities for better functioning of the harbour and benefit the people in an additional way.
5.	Strictly adhere to the rules prescribed under EIA Notification 2006 while implementing the project.	The Department of Fisheries would adhere to the rules prescribed in the EIA Notification, 2006, during the construction and operation phases of the project.
6.	The fishing harbour should be implemented without affecting the surrounding villages of the project location.	Precautionary measures will be implemented in order to ensure the surrounding villages and environment are not affected due to the

S.No	View / Concerns	Response
		proposed developments. Additionally the EMP measures suggested in the EIA Report will be implemented and monitored to ensure that the proposed project does not affect its surrounding environment.

7.1.2 Alamparaikuppam

The Public Hearing for proposed Fishing Harbour at Alamparaikuppam Village was conducted on 29.01.2021 at Sri Sairam Mahal, Door No.19/6, Thenpakkam, ECR, Kolathur Post, Cheyyur Taluk, Chengalpattu District (3 km from proposed project site) and the summary of views / concerns raised during the public hearing is presented below:

A total of 157 people had attended the meeting chaired by Mr. A. Rajagopalan – District Revenue Officer Chengalpattu Dist. And D. Vasudevan – DEE, TNPCB, Maraimalai Nagar. The advertisement for Public Hearing were published in English and Tamil daily newspapers on 10.12.2020.

A total of 18 views/concerns were raised by public during the event and majority of them welcomed the project considering its benefits to the people and others were welcoming the project but requested for the Esurance of no other impact on their livelihood, surrounding environment, possible pollution sources etc; the summary of the same is presented in **Table 7-2.**

Table 7-2 - Summary of Views/Concerns of Public Hearing at Alamparaikuppam, Chengapattu District

S.No	View / Concerns	Response
1.	It was stated that people of 4, 5 villages are fighting for this project for more than 40 years. Since there is no harbour around this area they have to spend around Rs.130 for tractors to take their boats from land to the sea and similarly around 500 boats are using tractors. So all those money spent for tractors	The project would improve the livelihood of the people of the fishing village of Alamparaikuppam by reducing the extra expenses that were spent for movement of fishing boats from the estuary to open sea by tractors.

S.No	View / Concerns	Response
	will become earning once this project is commenced.	
2.	Few suggested that it would be helpful if the proposed harbour is setup in sea front instead of Kaluveli waters as in Kasimedu fishing harbour.	Having a harbour developed similar to that at Kasimedu would require high quantity of dredging for the development of the harbour basin. Further, a sea front fishing harbour would cause higher damage at times of cyclonic activity, whereas in the case of Kaluveli Waters, the strength of the surge would be dissipated by the force of the cyclone.
3.	The proposed project will affect the livelihood of nearby village community and women who catch fish with bare hands and also will affect the salt pan of Marakanam, Villupuram District which is the third largest salt pan in Tamilnadu.	The proposed project would improve the flow of water into the creek caused by tidal fluctuation, which will improve the species diversity and density of estuarine organisms which would only enhance the livelihood of small scale fisherfolks who practice fish catching with bare hands. The project will not affect the livelihood of the people in a negative manner.
4.	In kaluveli waters if 1000 nos of boats are engaged, then the diesel oil used by the boats will spill and affect the salt pans, agricultural lands and the livelihood of village community who catch fish using bare hands	The boats that would be operated will be monitored for wear and tear periodically and be repaired. Such act of periodical monitoring would not cause the occurrence of any oil spills in Kaluveli Waters. Also the proposed fishing harbour will be equipped with oil spill mitigation equipments such as skimmers and booms. It is also proposed to appoint an environment monitoring cell.
5.	The project is welcomed if adequate measures	The fish catch will be brought to the harbour

S.No	View / Concerns	Response
	are taken up to control the environmental impacts and problems due to increase in the traffic are addressed properly	in the wee hours of the day and be transported to the nearby local markets and to the ports for export by 8:00 AM. The early transport of the fish catch from the harbour would not cause any hindrance to the local traffic. 4 HMV and 34 LMV would be used for the transport of fish catch from the harbour. Also the proposed fishing harbour will have approach road of width 10 m to prevent traffic congestion at the harbour entrance.
6.	Concern was raised regarding the Government's choice of establishment of the harbour in kaluveli back water instead of sea front, as it will affect the livelihood of the villages along the back waters especially dalit women who catch fish, prawn and crab by bare hands in the back waters. Due to the proposed project the water quality will be affected by the wastes and oil spillage from boats.	The development of the proposed fishing harbour at Alamparaikuppam would benefit the fishing communities irrespective of the sect or caste. The opening of the estuarine mouth would only enhance the species diversity and density. No discharge of waste water into the Kaluveli Waters from the harbour or the boat is envisaged as the wastewater will be treated in the proposed STP of 15 KLD Capacity.
7.	Adequate steps to be taken to reduce the erosion effects due to this proposed project as it was evident from the fact that because of Kasimedu Harbour the nearby villages were affected	3 numbers of short groynes is proposed as part of management plan which will control the erosion that is predicted to occur on the northern side of the coast.
8.	During heavy cyclone because of the river mouth, sea water enters the village easily and people are getting affected hence, to Build a protection wall for preventing this issue	Necessary hydrodynamic/ flood modeling studies was conducted to assess the impacts. Based on the modeling results size of the creek opening and location of training wall has been proposed to facilitate easy flow into the creek. The training wall will act as barrier

S.No	View / Concerns	Response
		between the direct sea currents and reduce their influence into the backwaters hence the scenario of seawater entering into the villages during unfair weather conditions will be mitigated.

The Minutes of Meeting of Public Hearing conducted for proposed fishing harbour at Azhagankuppam and Alamparaikuppam villages is presented in **Annexure XIII**

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 **Annexure XIV**.

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

Proposed Development	CRZ Area
Proposed Fishing Harbor	CRZ – IB, III
Proposed Training Wall	CRZ-IB, IVA.
Proposed Dredging	CRZ-IVB
Proposed Reclamation	CRZ – IB, III

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.

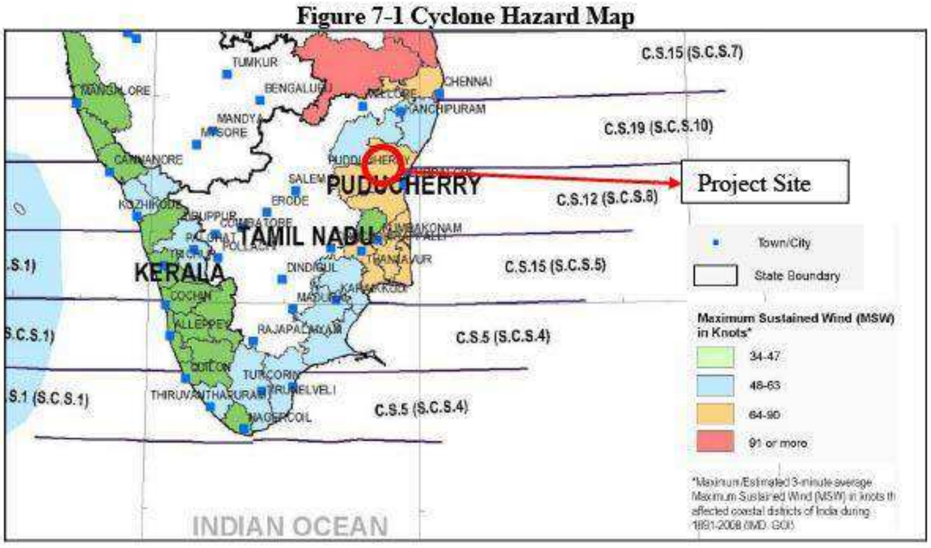
7.3.1 Natural Disasters

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 more number of cyclones. The cyclone hazard map published by Building Materials and Technology Promotion Council (BMTPC) is shown in **Figure 7-1**. 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).

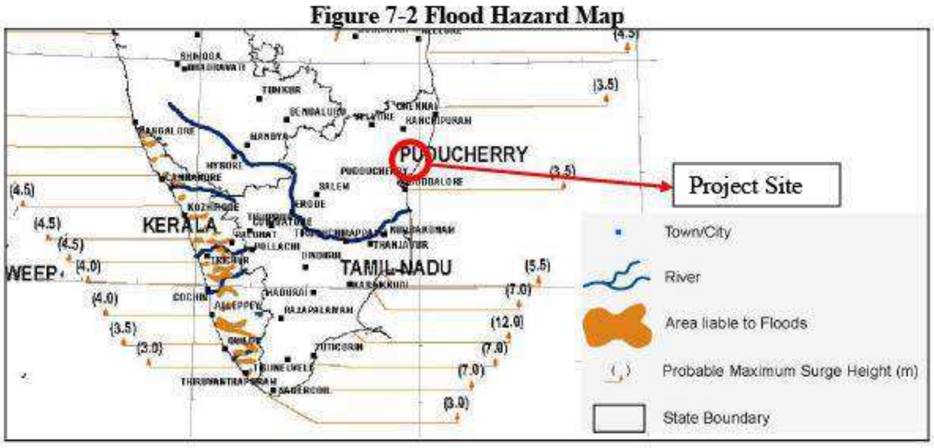
Figure 7-1 Cyclone Hazard Map



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 7-2**.

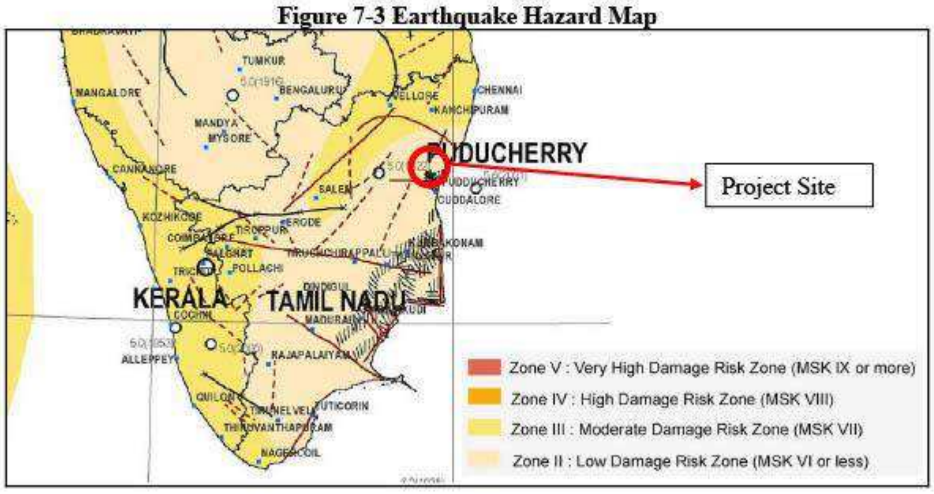
Figure 7-2 Flood Hazard Map



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 7-3**. The intensity of past earthquakes that hit Chennai region was in the range of 4.5-4.99 Mw (Moment Magnitude Scale)[9].

Figure 7-3 Earthquake Hazard Map



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

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 equipments 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 fire fighting instruments shall be located as follows,

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 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 equipments.
- 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 equipments 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.

The fisheries department shall prepare a Tier 1 Oil Spill Contingency Plan and be approved by the Indian Coast Guard for implementation at time of any unforeseen / accidental oil spill occurs at either of the proposed fishing harbour.

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.

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 –

9.1.1 Construction Phase Management Measures

9.1.1.1 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.

9.1.1.2 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

9.1.2 Operation Phase Management Measures

- 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

9.2 Noise Quality Management Plan

9.2.1.1 Construction Phase Management Measures

- 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.

9.2.1.2 Operation Phase Management Measures

- 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.

9.3 Water Quality Management Plan

9.3.1 Construction Phase Management Measures

- 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.

9.3.2 Operation Phase Management Measures

- 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.

9.4 Soil Quality Management Plan

9.4.1 Construction Phase Management Measures

- 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.

9.4.2 Operation Phase Management Measures

- 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.

9.5 Waste Management Plan

9.5.1 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.

9.5.2 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.

9.5.3 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.
- Bio degradable waste to the tune of 40 Tonnes per annum from each fishing harbour is expected to be generated which will be disposed through authorized vendors.
- 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.

9.5.4 Plastic Waste Management

- The use of plastics within the fishing harbour should be limited to the maximum extent which would avoid the generation of plastic waste at the site.
- Non-biodegradable waste to the tune of 10 Tonnes per annum is expected to be generated from each fishing harbour which will be disposed through authorized vendors.
- The plastic wastes that would be generated within the harbour facility should be sort, segregated and stored separately.
- The fisheries administration should ensure that no damage is caused to the environment due to plastics used within the harbour facilities
- The fisheries administration should also create awareness among its stakeholders on limited use of plastics.
- Each facility within the fishing harbour should be provided with a plastic waste collection bin.
- The plastic waste generated within the facilities should be recycled through TNPCB authorized vendors.

Further to the aforementioned the fisheries department should encourage its stakeholders to comply with the Tamil Nadu Government Order (Ms) No. 84 Environment and Forest (EC.2) Department dated 25.06.2018 regarding ban on one time use and throw away plastic irrespective of thickness with effect from 01.01.2019 under Environment (Protection) Act, 1986. This measure would enable limiting of plastic waste generation within the harbour facilities.

9.5.5 Fish Waste Management

Any fishing harbour would generate an ample amount of fish waste, that are considered inedible by humans, due to the cutting of fishes by local vendors within the harbour facility. These wastes are called fish offal, and management of those are a major task among all other wastes generated within the fishing harbour.

- All the fish offal generated within the harbour facility should be collected and stored in a separate storage area
- The fish offal should be explored for reuse as fish meal or fish sillage for poultry, animal husbandry, and aquaculture industry.
- The fish offal should be stored in airtight containers.
- These containers shall be placed at various points around the harbour area, including fish handling ad auction area and points of sale.
- The containers should not be placed around corners and should be placed at points without being hidden from sight.
- Also, the containers should be placed in cool shelter places that are away from direct sunlight.
- The offal collected should weekly be shipped to the fish meal / silage processing centers to avoid any spoilage.

9.6 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.

9.7 Wastewater and Sewage Management Plan

The wastewater from the port activities will be treated in the STP of 15 KLD capacity. The oil and grease from the harbours' workshops area, vehicle parking area, auction hall, fish handling area, administrative buildings, ice plants, storage areas etc. The wastewater after treatment in STP will be used for non-potable purposes within the harbour facilities and irrigation of the proposed greenbelt in the harbourt. This will help in the reduction of freshwater usage.

9.7.1.1 Discharge from Harbour Facilities / Infrastructure

- Periodical analysis of marine water quality in the area will be done in line to the environmental monitoring plan to assess any changes in the baseline water quality.
- If any changes are found, the possible source will be identified and addressed based on requirement.
- The runoff water from the ground will be provided with runoff drains connected to the STP for treatment and reuse.
- No waste water from the harbour will be discharged into the marine environment.
- The natural slope and drainage patter of the area shall be taken into account and the facility shall be constructed with slope towards the land area for the ease of collection of runoff water for treatment in the STP.

9.8 Marine Environment Management Plan –

9.8.1 Construction Phase Management Measures

9.8.1.1 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

9.8.1.1.1 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

9.8.1.1.2 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.

9.8.1.1.3 Disposal of Dredged Material

- Dredged material should be analysed in order to select appropriate disposal options (land reclamation).
- In the current proposal, the dredged 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.

9.8.1.1.4 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.

9.8.1.1.5 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.

9.8.2 Operation Phase Management Measures

The proposed fishing harbour will handle 12,000 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.

9.9 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.

9.9.1 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.

9.9.2 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 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 SOx, NOx, particulate matters, CO2, 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.

9.10 Mangrove Afforestation and Management Plan

The proposed development of fishing harbours, especially at Alamparaikuppam causes disturbances to small mangrove vegetations that are sporadically found at the proposed site. The mangroves that would be disturbed will be compensated through plantation by three folds at suitable locations that has been identified by Annamalai University. The details of which are as presented below.

9.10.1 Objective

1. To establish mangrove nursery for the afforestation.
2. Establishment of fringe mangrove in the manmade canal
3. To maintain mangrove genetic diversity in the ecosystem

9.10.2 Establishment of Nursery

The present proposal is aimed to establish the mangrove nursery and afforestation in and around Kaluveli Estuary. About 25,000 mangrove samplings belonging to five mangrove species would be established in an area of roughly 9.0 ha.

9.10.3 Candidate Species for Nursery

The following species are proposed for raising in the Nursery for the afforestation programme:

1. *Rhizophora apiculata*
2. *R. mucranata*
3. *Avicennia marina*
4. *A. officinalis*
5. *Exocaria agallocha*

To maintain the genetic diversity in the ecosystem, the following species would also be planted along with the above said candidate species, and these will be selected from the different mangrove ecosystem of India.

1. *Agiceras* sp
2. *Bruguira* sp
3. *Xylocarpus* sp

9.10.4 Nursery techniques

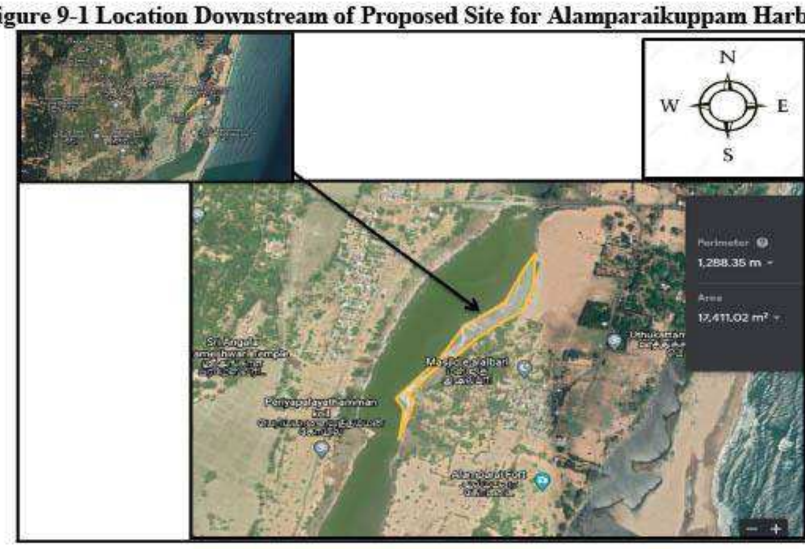
S. No	Techniques	Species	Remarks
1	Poly-bag nursery	*A. marina, A. officinalis, B. cylinrica, E. agallocha. Rhizophora apiculata* and *R. mucronata*	The growth of the plants will be faster in the poly-bag type of nurseries.
2	Air layering	*E. agallocha*	Due to poor seed germination, this particular species would be air-layered from the main tree from Pichavaram.

9.10.5 Probable Locations for Plantation

Predominantly intertidal areas in Kaluveli waters are identified for mangrove plantation.

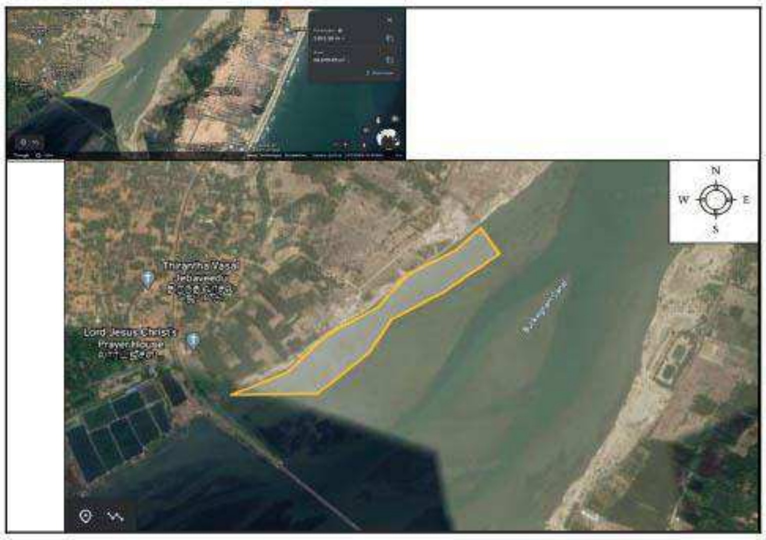
Location downstream of proposed fishing harbour at Alamparaikuppam - 1.75 ha Intertidal region suitable for mangroves

Figure 9-1 Location Downstream of Proposed Site for Alamparaikuppam Harbour



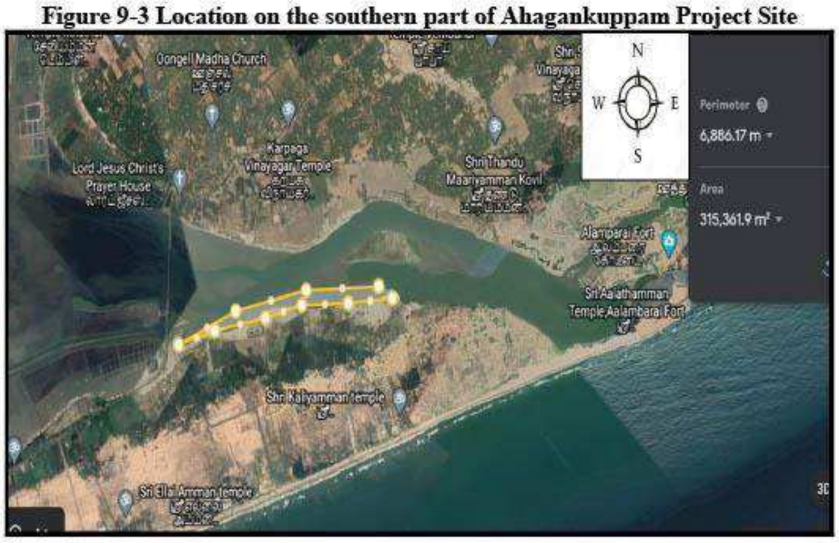
Location on the opposite banks of the proposed site for Azhagankuppam - 3.0 ha Intertidal region suitable for mangroves (scattered areas)

Figure 9-2 Location on Opposite Banks of Azhagankuppam Project Site



2.0 ha Intertidal region suitable for mangrove plantation (scattered areas) south of the proposed fishing harbour site at Azhagankuppam.

Figure 9-3 Location on the southern part of Ahagankuppam Project Site



9.10.6 Seed/Propagule source

Seeds and the propagules will be collected from the existing mangrove areas of Pitchavaram, Coleroon, Muthupet and also from various other mangrove forests of India (east and west coasts)

9.10.7 Methodology to be adopted

The regions which are suitable for mangrove plantations are receiving neither the tidal water nor the fresh water run-off due to chronic siltation. Therefore, establishment of manmade canals would facilitate tidal water flow, which is essential requirement for mangrove establishment. The fish bone shape canal method of mangrove restoration will be adopted for the elevated or silted sites. Open intertidal areas would be planted by the mangrove samplings/ propagules directly. The detailed report of Annamalai University is provided in the **Annexure XII**.

9.11 Management of Turtle Movement

As there is sporadic nesting of turtles in the shores of Kaluveli as detailed in the Annamalai University, the following measures are to be taken to mitigate and manage the impact on turtles.

- The fixture will be mounted as low as possible to minimize light trespass and the lowest amount of light needed for the task shall be used.
- Long wavelength lights will be used wherever possible. Low pressure sodium (LPS) lights are considered more desirable than HPS sources. Short wavelength (blue) and broad spectrum sources such as metal halide, mercury vapour, fluorescent or halogen lights will be avoided.
- Amber filters on HPS lights will be used if HPS lights use cannot be avoided,
- White lights that emit ultraviolet light will not be used.
- Strong blue or green spectral elements (e.g. mercury vapour lights) will be limited as far as possible.
- Lights will be directed downward and will be shielded to avoid overhead glow on cloudy nights
- To mitigate the erosion related issues, sand by passing / Beach nourishment is considered as one way to mitigate erosion.
- Dredging should be carried out during non-nesting season.

- The vegetation to be carried out in the region should comprise only the native species.
- Facilitate the fisherman to attach Turtle excluding device (TED) to the trawl net to minimize the accidental catch of turtles.
- The extraction of sand from the coastal line or beaches alters the topography affecting the vegetation, sand dunes and thus the natural habitat of the Turtles and therefore it will be strictly prohibited.
- Awareness programmes for local fisher population, company labourers and employees shall be undertaken to highlight sea turtle conservation. Awareness regarding fisheries related issues is also necessary among fishing community. Incidental capture of turtles in shrimp trawls and gill nets account for more deaths than all other human activities combined. In addition to the trawl entanglement, sea turtles have been killed after becoming entangled in other types of fishing gear, such as, gill nets, long lines (hook and line), and lobster or crab pot lines. Creation of awareness among villagers and fishermen shall be undertaken as part of conservation measures.

9.12 OHS Management

- Proper planning and execution of transportation schedule of raw materials will be done ensuring no disturbance to regular movement of vehicles in the region from the existing fishing activities in the area and public vehicle movements.
- Buoys/signboards will be utilized for the demarcation of the construction site with adequate enclosures.
- Periodical inspection of construction equipment and machinery should be done and replacement of any faulty units will be done immediately.
- Any repair and maintenance works of these equipment/ machinery will be done inshore in designated areas and away from the water bodies.
- All fuelling operations of these units will also be done in designated areas inshore and away from water bodies.
- Storage of fuel, oil and other construction material will be done in areas with proper lined floors and inventory quantity will be maintained to feasible levels and not over stacked.

- A minimal setback distance of 20m shall be maintained for raw material storage from the waterfront area with proper enclosure to prevent the construction materials from entering the water body.
- In general the material storage can be done in close units such as warehouse or sheds with proper lined floors and drain units. This will be of great help in reducing the dust emissions and curb the runoff water from entering into the open environment especially during monsoon season.
- In case of easy access to the materials, open storage will be done and the materials will be covered with tarpaulin sheets.
- No disposal/discharge of waste will be done into the water body.
- The concrete pumping unit and transportation pipes will be inspected from any leaks or failure, in case of any such unlikely event the activates will be temporarily suspended and resume only after addressing the issue.
- Hazardous materials such as used spent oil, oil-soaked cloth waste, empty paint tins, etc will be disposed through authorized vendors.
- Adequate soil support should be provided in the reclamation area to bear the weight of the proposed fishing harbours and prevent any structural failure.
- Construction site should be equipped with spill control units, silt screens installation and sheet piling will be done to contain and remove any oil spill and prevent the dispersion of any spilled materials in the water.
- Construction activities should be executed in correlation with the weather forecast and suspension of construction activities during unfavorable weather conditions.
- Temporary suspension of construction activity during construction phase and harbour operations during operation phase will be done during highly unfavorable weather conditions.
- Spill control equipment will be installed in the berth areas and periodical inspection of the same will be done.

9.12.1 Post Covid Health Management

Due to the current Covid-19 pandemic that has crippled the normal life of people, the safety of workers and local people should be considered at places of major construction due to the movement of people during the construction phase of the project as well as the operation phase. Therefore, the Department of Fisheries, Government of Tamil Nadu should take utmost precautions and care for the health of the workers. To uphold this commitment is it encouraged and suggested that the Department strictly abides with the "Post COVID Management protocol" published on 13th September 2020 by the Emergency Medical Relief Division of the Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India.

9.13 Administrative Aspects

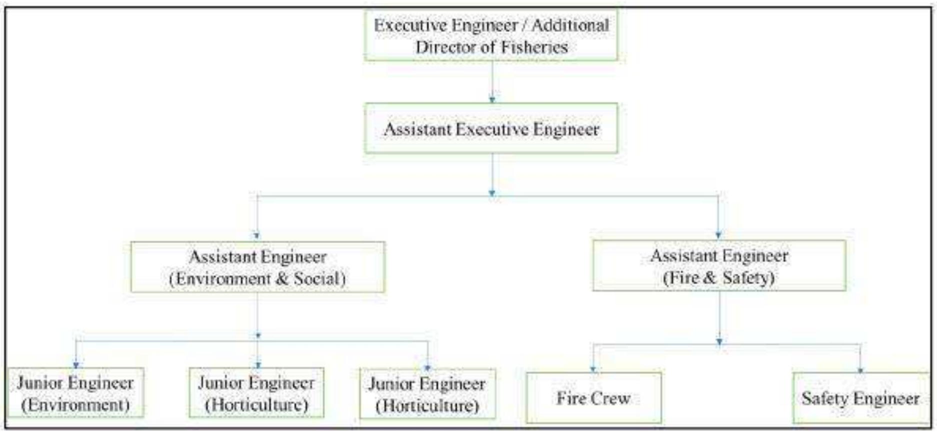
The key benefits of EMP are that it provides the organization with the means of managing and improving its environmental performance thereby allowing it to contribute to better environmental quality. In order to administer the Environment Management Plan and to monitor its efficiency it is a mandate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

9.14 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



9.15 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.

9.16 Implementation of Environmental Management Plan and Monitoring Program

The Environment Cell will ensure implementation of the EMP and the monitoring program designed for the proposed project during its the construction and operational phase of the project and documenting the effectiveness of the same. It will extend and strengthen their function in overseeing the implementation and evaluation of the environmental management measures that are to be recommended for the development of the proposed fishing harbours.

9.16.1 Audit and Inspection

The Environment Cell shall be responsible for implementing the Compliance Assurance activities, namely environmental audits. The audits and reviews of environmental procedures shall be conducted annually internally and also by an external agency of repute once in two years. Besides, a quarterly EHS performance reviews should also be conducted internally by the Department of Fisheries. Any whole or partial change to the environment is identified and evaluated, corrective measures should be taken for the betterment of the environmental condition. Periodic inspections and record keeping are measures of how effective the programs are and facilitate identification of areas where improvement is necessary. Environmental inspections will examine all activities and document those actions that are carried out in compliance with environmental permits, specifications relating to environmental protection, and mitigation plans.

9.17 Cost of Environment Management Plan

The Department of Fisheries will implement the environmental management plan that was detailed on the above sections of this chapter in order to sustain the surrounding environment from being affected by the activities of the proposed fishing harbours at Azhagankuppam and Alamparaikuppam. In order to implement those, a budgetary allocation of 4.9 Crore has been charted for those infrastructures and is presented in the table below.

Table 9-1 Cost of Environment Management Plan

S.No	Description	Cost in Crore	
		Azhagankuppam	**Alamparaikuppam**
1	Sewage Treatment Plant	0.75	0.5
2	Greenbelt Development	0.09	0.05
3	Stormwater Drains	1.3	0.2
4	Soild Waste Management	0.23	0.23
5	Fish Waste Management	0.4	0.4
	Sub Total	***2.77***	***1.38***
	Total	**4.15**	
6	Mangrove Management Plan	0.75	
	Grand Total	**4.9**	

9.18 Corporate Social Responsibility (CER)

Although no concerns were raised in the public hearing conducted for Alamparaikuppam and Azhagankuppam fishing harbour projects, the Department of Fisheries is planning to allocate a sum of Rs.6.335 Crores as Entrepreneur Social Commitment (ESC) in the best interest for the public welfare which includes activities such as access road for public, public over head water tanks. The cost breakup of the proposed developments are given in **Table 9-2**.

Table 9-2 Entrepreneur Social Commitment

Development Proposed	Cost in Crores	
	Azhagankuppam	Alamparaikuppam
Access road for the Public	3	3
Public Over Head Water tank	0.167	0.168
Total	**3.167**	**3.168**
Grand Total	**6.335**	

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.

ANNEXURE-8

MARINE BIODIVERSITY IMPACT ASSESSMENT, MANGROVE AFFORESTATION AND TURTLE CONSERVATION FOR CONSTRUCTION OF FISHING HARBOUR IN KALUVELI WATERS AT AZHAGANKUPPAM IN VILLUPURAM (DT.) AND ALAMPARAIKUPPAM IN KANCHEEPURAM (DT.)

Research Team

Principal Investigators

Dr. P. Murugesan
Dr. A. Gopalakrishnan
Mr. T M Vasanthan

Research Personnel

Dr. G. Mahadevan (Research Associate)
Dr. P. Damotharan
Dr. V. Bharathidasan
Mr. R. Punniyamoorthy
Mr. P. Partha Sarathy
Mr. N. Honestraj

Centre of Advanced Study in Marine Biology
Faculty of Marine Sciences
Annamalai University
Parangipettai – 608 502

December 2020

CONTENTS

MARINE BIODIVERSITY IMPACT ASSESSMENT, MANGROVE AFFORESTATION AND TURTLE CONSERVATION FOR CONSTRUCTION OF FISHING HARBOUR IN KALUVELI WATERS AT AZHAGANKUPPAM AND ALAMPARAIKUPPAM

1. Preamble

Tamil Nadu Government is keen to expand the fishing harbours and fish landing Centers towards hygienic handling of fishes and thereby ensuring higher cost for the fishes. Construction of fishing harbours and fish landing centers offer a new dimension to the livelihood of the fishing community and accordingly the new fishing harbours are mooted with ancillary facilities, like auction hall, net mending shed, ice plant etc. Following this plan, Government of Tamil Nadu has already completed many fishing harbours and fish landing Centers in both east and west coasts of Tamil Nadu. Regrettably, there is no fishing harbor facility in Villupuram and Kancheepuram districts. Hence the Government of Tamil Nadu proposed to construct fishing harbours for safe berthing of fishing boats operated by fishers of Villupuram and Kancheepuram Districts.

Kancheepuram district is bounded in the south by Villupuram district. The district has a total geographical area of 4393.37 Km^2 and coastline of 87.2 Km. Villupuram district of Tamil Nadu is spread over an area of 7,250 Sq. km. and has a coastal length of 40.7 kms. Villupuram district contains 19 coastal fishing villages and has 20 mechanized fishing boats, 1292 motorized crafts and 1016 traditional fishing crafts. Similarly, the Kancheepuram district has 12 mechanized fishing boats and over 2000 motorised and traditional fishing crafts. Accordingly, a total of 100 fishing vessels in each harbour are expected to be anchored after the completion of the proposed fishing harbors. The nearest existing fishing harbour is around 105 km away at Chennai (north) and at Puducherry (south) which is approx. 42 km away. The existing fishing harbours in the state are already teemed with and therefore, the proposed harbors will help in reducing the fishing pressure besides this will also help in promoting deep sea fishing.

Further, the proposed harbour will improve the socio-economic status of the fisher folk/entrepreneurs and will also provide employability to the local fisher folk in and around the fishing villages of Villupuram and Kancheepuram district. Fishery sector is emerging as a viable sector contributing towards employment generation in fishing and allied activities, supplementing food supply, raising nutrition level and earning foreign exchange through exports. Export of marine products play a vital role in fisheries development in India by providing employment and income to millions engaged in fishing, aquaculture processing and allied activities. This sector if developed appropriately could make India as one of the top exporters of marine products in the world.

As the total fish handling capacity of the proposed fishing harbor is more than 12000t/annum, it is essential to get environmental clearance from the State Expert Appraisal Committee (SEAC), as it falls under "Category B" project according to the EIA notification 2006 [S.O.1533 (E), dated the 14th September, 2006]. The proposed project also requires prior CRZ clearance from the SEAC according to the CRZ notification 2011 and therefore a detailed biodiversity impact assessment study and environment management plan to be carried out through an Institute of repute on marine, brackish water and freshwater ecology and biodiversity for getting the environmental clearance. The report should include the impacts of the proposed project on the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, sub-tidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds mangrove etc. Therefore the Department of Fisheries, Tamil Nadu engaged the services of Centre of Advanced Study in Marine Biology, Annamalai University", a well reputed and pioneering marine institute having vast experience in assessment of coastal and marine biodiversity, for carrying out the above referred study.

Accordingly, the Experts from Centre of Advanced Study (CAS) in Marine Biology of Annamalai University, Tamil Nadu have carried out Marine Ecological feasibility survey on 12th and 13th December 2020 at Kaluveli coastal waters, creeks and intertidal areas. During survey, data on sea water, sediment and biological samples (Plankton, Benthos, microbiological and other ecologically important flora and fauna including mangrove and turtle movement) were collected from 12 different stations. The latitude and longitude of the sampling stations are given in Table 1 and also in Map (Figure.1).

2. Objectives of the study

Based on the primary data and also appending with secondary data, the EIA report has been prepared to meet the following objectives:

a) To study and analyze the anticipated impacts of the proposed project on overall baseline environmental and biological conditions in the proposed area;

b) To identify environmental sensitive features within the study area for safe guarding the biodiversity potential;

TABLE -1. SAMPLING STATIONS AND THEIR GEOGRAPHICAL CO-ORDINATES

S. No.	St. Code	Latitude	Longitude
1.	**KBW 1**	12°15'48.43"N	80° 0'44.14"E
2.	**KBW 2**	12°15'25.50"N	80°00'22.98"E
3.	**KBW 3**	12°15'20.96"N	80°00'06.79"E
4.	**KBW 4**	12°15'08.46"N	79°59'34.42"E
5.	**KBW 5**	12°14'42.25"N	79°59'04.62"E
6.	**KBW 6**	12°14'10.51"N	79°58'36.90"E
7.	**KBW 7**	12°13'50.86"N	79°58'09.64"E
8.	**KBW 8**	12°13'31.61"N	79°57'33.69"E
9.	**KBW 9**	12°130'0.64"N	79°56'58.66"E
10.	**KBW 10**	12°12'43.94"N	79°56'21.58"E
11.	**KBW 11**	12°12'5.77"N	79°55'48.26"E
12.	**KBW 12**	12°11'42.13"N	79°55'16.77"E

Fig. 1. Map showing the stations in Kaluveli Backwaters

RESEARCH TEAM

3. MATERIALS AND METHODS

3.1. Water and Sediment Sampling

Water samples were collected using Universal water sampler both in the surface and sub-surface level and transferred to the pre-cleaned polypropylene and glass containers. Sediment samples were collected using Van-veen Grab, transferred to clean polythene bags and transported to the laboratory. After removing the plant root and other debris, the samples were air-dried and stored for further analysis.

3.1.1. Water Analysis

Temperature, Salinity and pH

The physical parameters such as temperature, salinity and pH were measured *in-situ* in the field. The subsurface temperature was measured with a mercury thermometer (±0.02°C accuracy) and the pH was measured by a calibrated pH pen (pH ep-3 model). Salinity was estimated using a Hand Refractometer (Atago, Japan). Water samples collected for dissolved oxygen estimation were transferred carefully to BOD bottles. The DO was immediately fixed and brought to the laboratory for further analysis.

Preservation and Laboratory Analysis

After collection, the samples were immediately cooled to 4°C and then brought to the laboratory in an insulated thermocool box. In the laboratory, water samples were filtered through Whatman GF/C filter paper and analysed for organic matter and other nutrients. Unfiltered samples were used for the estimation of total nitrogen and total phosphorus. All the analyses were carried out by adopting Standard procedures for samples of aquatic origin. Briefly, the methodology for each analysis is given below:

Dissolved Oxygen

The modified Winkler's method as described by Strickland and Parsons (1972) was adopted for the estimation of dissolved oxygen. The values are expressed in mg/l.

Nitrate and Nitrite

The nitrate and nitrite content of samples were analysed by following the methods described by Strickland and Parsons (1972). The nitrite was estimated from highly coloured azo dye formed by the addition of N (1-Napthyl) ethylene diamine di hydro-chloride and sulfanilamide into the solution was then measured at 543 nm in a spectrophotometer. The same procedure was followed for the estimation of nitrate. For this, nitrate was reduced to nitrite by passing the sample through copper coated cadmium column. The values are expressed in μmol of Nitrogen/l.

Inorganic Phosphate

The single solution mixed reagent procedure developed by Murphy and Riley (1962) was followed for the estimation of dissolved inorganic phosphate levels in water samples. This involves the conversion of phosphate into phosphomolybdic acid, which was then reduced to molybdinum blue color complexes and then the intensity of colour was measured at 882 nm in a spectrophotometer. The calculated values are expressed in μmol of Phosphorus/l.

Total Phosphorus

The Total Phosphate in samples was estimated by adopting the method described by Menzel and Corwin (1964). This procedure involves the conversion of organically bound phosphate into inorganic phosphate by wet oxidation of samples with potassium persulphate in an autoclave for 30 min at 15 lbs pressure. The converted inorganic phosphate was then estimated by using the method described by Murphy and Riley (1962). The subtraction of original dissolved inorganic phosphate from total phosphate yielded the organic phosphate in the water sample. The calculated value is expressed in μmol of Phosphorus/l.

Reactive Silicate

The reactive silicate content of water was estimated by following the method of Strickland and Parsons (1972). In this method, the intensity of blue color formed by silico-molybdate complex was measured in a spectrophotometer at 810 nm and the calculated values are expressed in μmol of Silica/l

3.1.2. Sediment Analysis

For the analysis of textural composition and pH, the air-dried sediment samples were used as such. For all other analyses of organic matter, sediment samples were ground to fine powder and dried in an oven at 110°C to constant weight for an hour.

Total Organic Carbon

The estimation of total organic carbon in sediment was performed by adopting the method of El Wakeel and Riley (1956). The procedure involves chromic acid digestion and subsequent titration against Ferrous ammonium sulphate solution in the presence of 1-10 Ferrous phenonthroline indicator. The values calculated are expressed in mg C/g of sediment.

Statistical analysis - Principal Component Analysis (PCA)

PCA is a powerful tool that attempts to explain the variance of a large dataset of inter-correlated variables with a smaller set of independent variables (Simeonov *et al*., 2003). PCA technique extracts the eigenvalues and eigenvectors from the covariance matrix of original variables. PCA is designed to transform the original variables into new, uncorrelated variables (axes), called the principal components, which are linear combinations of the original variables (Shrestha and Kazama, 2007). It reduces the dimensionality of the data set by explaining the co-relation amongst a large number of variables in terms of a smaller number of underlying factors, without losing much information (Vega *et al*., 1998; Alberto *et al*., 2001). This routine was adopted using the statistical programme PRIMER (Ver. 7.0) with a view to ascertain the relationship among the environmental entities studied in various stations of Kattupalli coastal waters (Clarke and Warwick, 2001).

3.2. Bacteriological Methods

3.2.1. Collection of samples:

Surface water samples were collected in 30ml sterile screw capped bottles for bacteriological assessment. Enough air space was left in the bottles to allow thorough mixing. Precautionary measures were taken to avoid contamination through handling. For microbial assessment in sediment samples, a known quantity of samples was collected from the grab samples using sterilised spatula. The central portion of the collected sediment was aseptically transferred into sterile polyethylene bags. All the samples were brought to the laboratory in portable icebox soon after collection and bacteriological analyses were carried out in the laboratory at CAS immediately, with necessary dilution.

3.2.2. Enumeration of Total Viable Counts:

TVC was enumerated by adopting the spread plate method using Zobell's Marine Agar medium (EA123, Hi-Media, Mumbai). The samples (water and sediment) were diluted using the sterile sea water and 0.1 ml of the diluted sample was pippeted into the petriplates containing Zobell's Marine Agar and it was spread using a 'L' shaped glass spreader. The plates after inoculation were incubated in an inverted position at a temperature of 28+2°C for 24to 48 h. The colonies were counted and the population density expressed as Colony Forming Unit (CFU) per ml or g of the sample. The bacterial colonies were picked up from the pertidishes and re-streaked in appropriate nutrient agar plates thrice before a pure culture was established in agar slants.

3.2.3. Enumeration of Total Coliforms:

Macconkey agar with 0.15% bile salt, crystal violet and NaCl has been recommended in accordance with USP/Nfxi (1) for the detection, isolation and enumeration of coliforms and intestinal pathogens in water, dairy products, pharmaceutical preparations, etc. The agar weighing 51.5 g in 1000 ml distilled water was heated up to the boiling point to dissolve the medium completely and sterilized by autoclaving at 15 lbs pressure (121°C) for 15 min. suitably diluted samples were inoculated in the petriplates containing medium and were incubated for 48 h. After incubation, the colonies of *E. coli* appeared with pink color.

M-FC agar is employed for detection and enumeration Faecal Coliforms by the membrane filter technique at higher temperature (44.5°C). The agar weighing 52 g was suspended in 1000 ml of distilled water and heated up to the boiling point to dissolve the medium completely, 10ml of Rosolic acid (dissolved in 0.2 N NaOH) was added, heated with frequent agitation and boiled for 1 min. Then the medium was cooled to 50°C. Finally, the medium was poured into small 60mm plates. Samples filtered by Millipore apparatus using 0.45μm Whatman filter papers were impregnated in the petriplates. After 48 h of incubation, the colonies of *E. coli* appeared with blue colour.

Principal Component Analysis (PCA)

PCA is a powerful tool that attempts to explain the variance of a large dataset of inter-correlated variables with a smaller set of independent variables (Simeonov *et al*., 2003). PCA technique extracts the eigenvalues and eigenvectors from the covariance matrix of original variables. PCA is designed to transform the original variables into new, uncorrelated variables (axes), called the principal components, which are linear combinations of the original variables (Shrestha and Kazama, 2007). It reduces the dimensionality of the data set by explaining the co-relation amongst a large number of variables in terms of a smaller number of underlying factors, without losing much information (Vega *et al*., 1998; Alberto *et al*., 2001). This routine was adopted using the statistical programme PRIMER (Ver. 7.0) with a view to ascertain the relationship among the environmental entities studied in various stations of Kattupalli coastal waters (Clarke and Warwick, 2001).

3.3. Chlorophyll `a':

The samples were filtered through Whatman GF/C filter papers and the chlorophyll was extracted into 90% acetone. The resulting colored acetone extract was measured in a spectrophotometer at different wavelengths and the same acetone extracts were acidified and measured for the phaeo-pigments. The detailed methodology as described in APHA manual (1989) was followed.

3.4. Phytoplankton:

Phytoplankton samples were collected from the surface waters of the study areas by towing a plankton net (mouth diameter 0.5 m) made of bolting silk (mesh size 20 micron) for half an hour. These samples were preserved in 5% neutralized formalin and used for qualitative analysis. For the quantitative analysis of phytoplankton, the settling method as described by Sukhanovo (1978) was adopted. Numerical plankton analysis was carried out using Utermohl's inverted plankton microscope.

Phytoplankton species was identified using the standard works of Hustedt (1930-1966), Venkataraman (1939), Cupp (1943), Subramanian (1946), Prescott (1954), Desikachary (1959 and 1987), Hendey (1964), Steidinger and Williams (1970) and Taylor (1976) and Anand *et al.* (1986).

3.5. Zooplankton:

Zooplankton samples were collected from the surface waters of the study areas by horizontal towing of plankton net with mouth diameter of 0.35 m, made of bolting silk (No. 70 mesh size 200 μm) for half an hour. After collection, the samples were preserved in 5 - 7% neutralized formalin and used for quantitative analysis. The zooplankton collected were identified to the species level using the classical works of Dakin and Colefax (1940), Davis (1955), Kasthurirangan (1963) and Wickstead (1965) and Damodara Naidu (1981). For the quantitative analysis of zooplankton, a known quantity of water (100l) was filtered through a bag net (0.33 mm mesh size) and filtrate was made up to 1 litre in a wide mouthed bottle and then enumerated using Utermohl's inverted plankton microscope. The plankton density is expressed as number of organisms/m^3.

3.6. Benthic Community:

For benthic organisms, sediment samples were collected using a Van veen grab which covered an area of $0.1m^2$. The wet sediment was sieved with varying mesh sizes for segregating the organisms. The organisms retained in the sieve were fixed in 5-7% formalin and stained further with Rose Bengal solution for easy spotting at the time of sorting. After a day or two, the organisms were sorted into various groups. The number of organisms in each grab sample was expressed as number per meter square. According to size, benthic animals are divided into three groups. (i) macrobenthos and (ii) meiobenthos and microbenthos (Mare, 1942). All the species were sorted, enumerated and identified to the advanced level possible with the consultation of available literature. The works of Fauvel (1953), Day (1967) were referred for polychaetes; Barnes (1980) and Lyla *et al*. (1999) for crustaceans; Subba Rao *et al.* (1991) and Ramakrishna (2003) for molluscs; Loeblich and Tappan (2015); Mohan et al. (2013) and Muruganantham et al. (2017) for foraminiferal; Chitwood (1958); Lambshed (2004); De Ley et al. (2005); Poinar (2008); Vovlas et al. (2011); Ahmed et al. (2015) for nematodes; Brouwers et al. (2000); Tanaka (2008) and Yasuhara et al. (2014) for ostracodes and Huys and Boxshall (1991); Wells (2007); Yeom and Lee (2020) for Harpacticoids.

Statistical Analysis

Cluster Analysis

The classification method, Cluster analysis was done to find out the similarities between the samples/ stations/regions. The most commonly used clustering technique is the hierarchical agglomerative method. The results of this are represented by a tree diagram or dendrogram with the x- axis representing the full set of samples and the y-axis defining the similarity level at which the samples or groups are fused. Bray – Curtis coefficient (Bray and Curtis 1957) was used to produce the dendrogram.

MDS (non - metric Multi-Dimensional Scaling)

This method was proposed by Shepard (1962) and Kruskal (1964). To confirm the clustering pattern, this was used to find out the similarities (or dissimilarities) between each pair of entities to produce a 'map', which would ideally show the interrelationships of all.

BIO-ENV procedure

In the present study, to ascertain the relationship between biological and environmental variables, the BIO-ENV procedure (Clarke and Ainsworth, 1993) was employed. The basic principle behind this is to measure the agreement between the rank correlations of the biological (Bray-Curtis similarity) and environmental (Euclidean distance) matrices. A weighted Spearman rank correlation coefficient ($\rho\omega$) was used to determine the harmonic rank correlation between the biological matrix and all possible combinations of the environmental variables.

VIEWS OF SAMPLING AREA

Proposed harbour-Alamparaikuppam

Alamparaikuppam Fort (now under restoration)

Avifauna-Near Alamparaikuppam Beach

Proposed Training wall/Groyne Site

Proposed Azhagankuppam harbour

Mangrove Zone

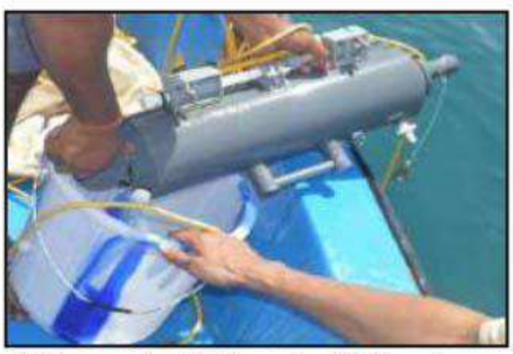
VIEWS OF SAMPLING ACTIVITIES

Research personnel in action

In-situ Temperature measurement using Thermometer

pH measurement using pH pen

Salinity measurement using Refractometer



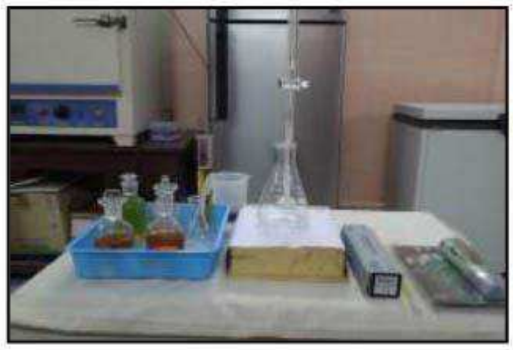
Water sample collection using Niskin water sampler

Plankton sample collection using Bongo net

Sediment sample collection using Van Veen Grab

Storing of sediment sample for TOC analysis

Sieving of benthic samples



DO estimation by following Winkler's method

4. OBSERVATION REPORT

4.1. Water Quality

Depth

The depth in the study area varied between 1.5 and 5.0m, with maximum at KBW-7 and minimum at KBW-12 (Fig. 2).

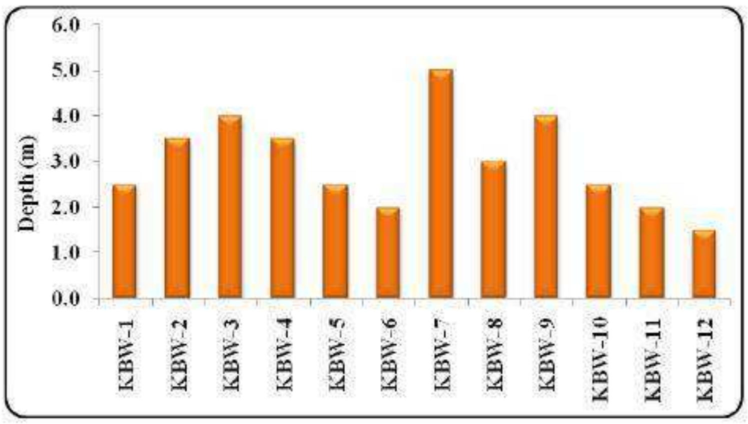


Fig. 2. Depth values recorded at various stations of Kaluveli backwaters

Water Temperature

The water temperature fluctuated from 24.0 to 26.5°C. The minimum value was recorded at KBW-10 and maximum was recorded at KBW-2 (Fig. 3).

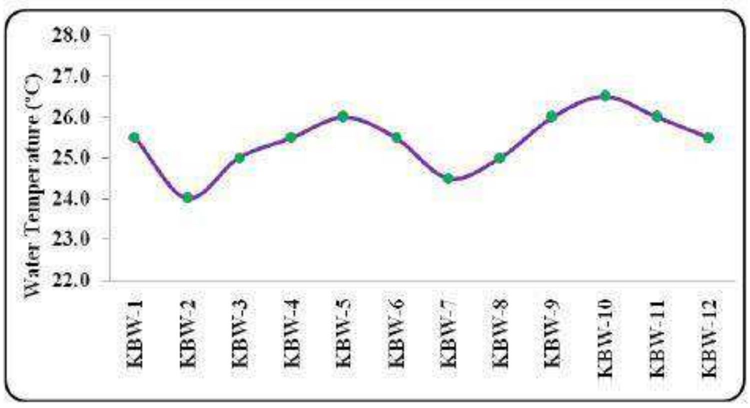


Fig. 3. Water temperature values recorded at various stations of Kaluveli backwaters

Salinity

The water salinity varied from 5.0 to 28.0PSU. The salinity was found to be lower at KBW-12 and higher value at KBW-1 (Fig. 4).

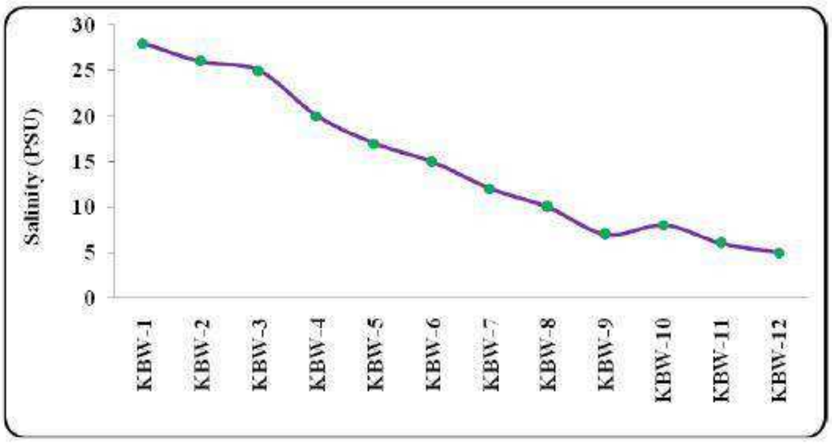


Fig. 4. Salinity level recorded at various stations in Kaluveli backwaters

Water pH

The water pH varied between 7.5 and 7.9 with minimum value was recorded at KBW-11 and maximum value was recorded at KBW-2 (Fig. 5).

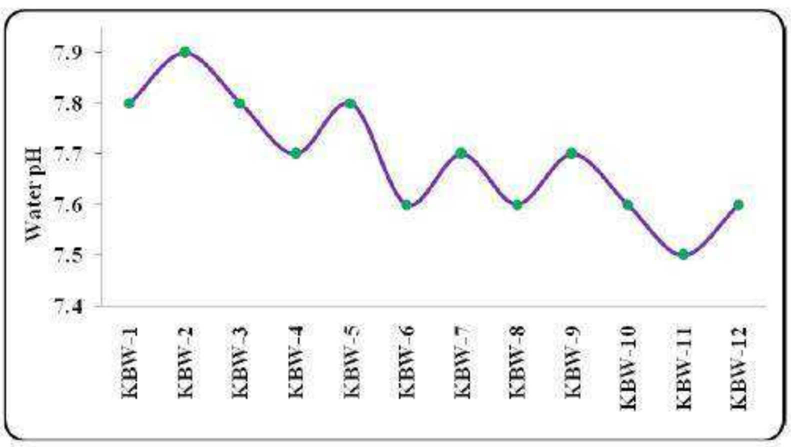


Fig. 5. Water pH level recorded at various stations of Kaluveli backwaters

Total Suspended Solids (TSS)

The Total Suspended solids values ranged between 89.5 and 120.6ppm. The minimum value was recorded at KBW-10 and the maximum was recorded at KBW-6 (Fig. 6).

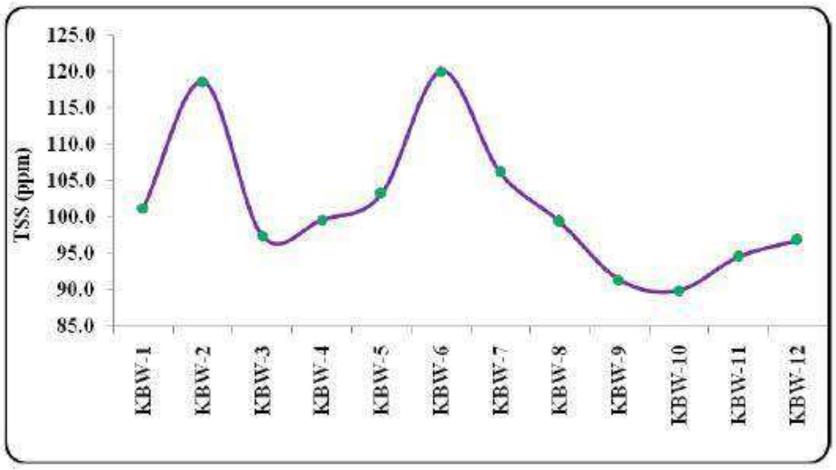


Fig. 6. Total suspended solids values recorded at various stations of Kaluveli backwaters

Turbidity

The turbidity values were between 7.3 and 8.4NTU. The minimum level was recorded at KBW-10 and the maximum level at KBW-6 (Fig. 7).

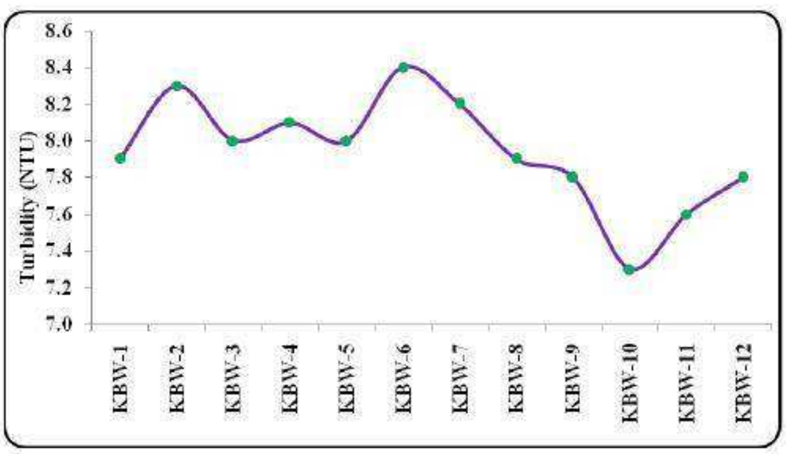


Fig. 7. Turbidity values recorded at various stations of Kaluveli backwaters

Dissolved Oxygen

The Dissolved Oxygen level in the water varied between 4.482 and 5.831 mg/l. The lower value was recorded at KBW-4 and the higher value at KBW-10 (Fig. 8).

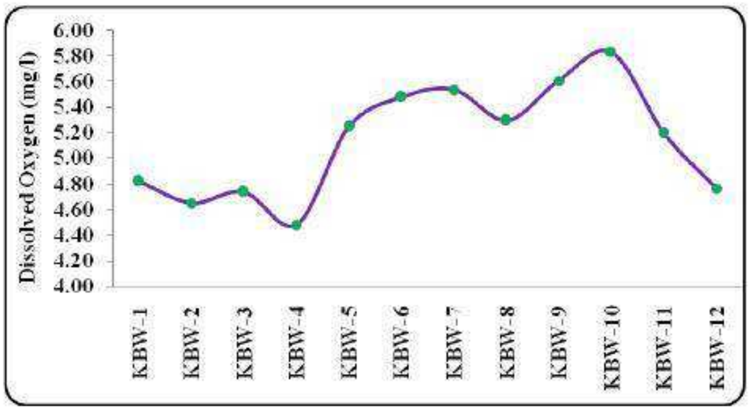


Fig. 8. Dissolved oxygen level recorded at various stations of Kaluveli backwaters

Biological Oxygen Demand

The BOD values varied between 0.546 and 1.024mg/l with minimum at KBW-9 and the maximum value was recorded at KBW-4 (Fig. 9).

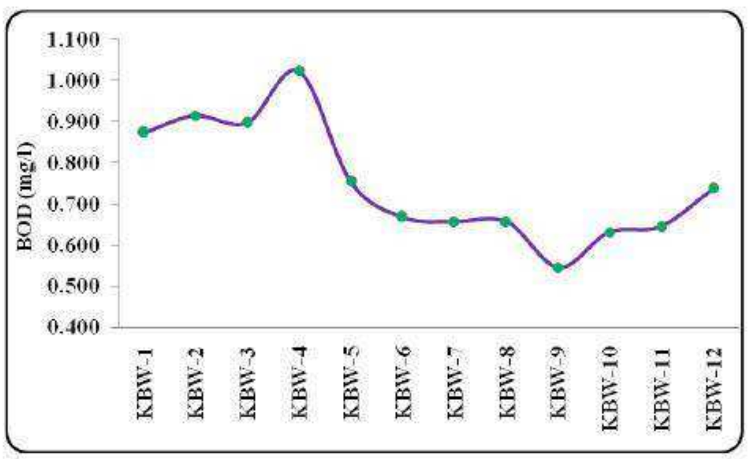


Fig. 9. Biological oxygen demand values recorded at various stations of Kaluveli backwaters

Nutrients

The life supporting processes in the sea requires an array of inorganic substances, of which, the role of nitrogen, phosphorus and silicon are considered to be very vital in marine ecosystem. Among the nitrogenous compounds, nitrite, nitrate and ammonia are the major constituents, which play a key role in the growth and proliferation of phytoplankton. Accordingly, the results of various parameters recorded in various stations of the study area are given below:

Nitrite

The nitrite level varied from 1.28 to 2.36µmol/l with maximum at KBW-11 and minimum at KBW-1 (Fig. 10).

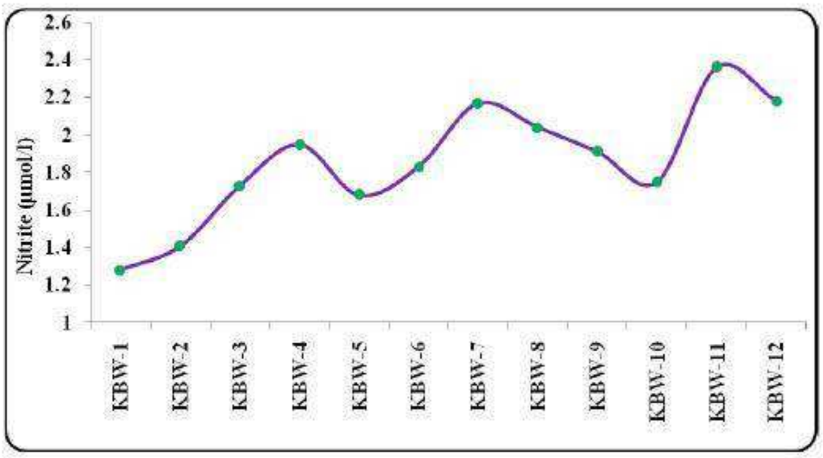


Fig. 10. Nitrite level recorded at various stations of Kaluveli backwaters

Nitrate

Nitrate concentration ranged between 1.87 and 3.27µmol/l with minimum at KBW-1 and maximum at KBW-12 (Fig. 11).

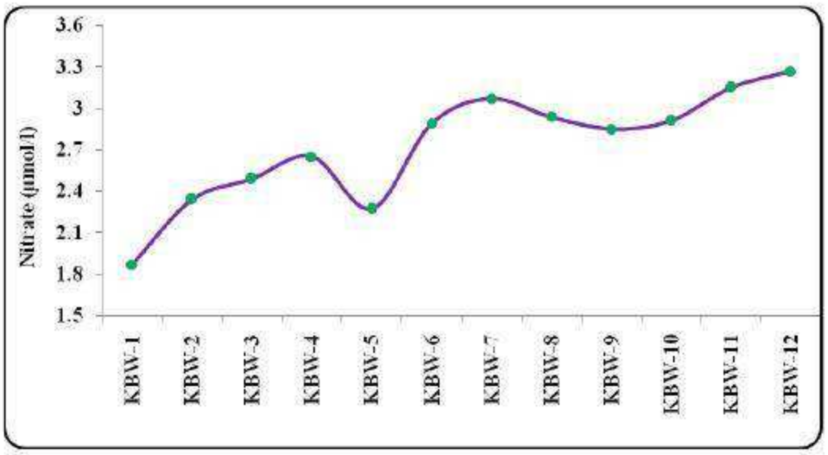


Fig. 11. Nitrate concentration recorded at various stations of Kaluveli backwaters

Total Nitrogen

The Total nitrogen values ranged from 13.92 to 22.18µmol/l. The minimum value was recorded at KBW-1 and the maximum value at KBW-11 (Fig. 12).

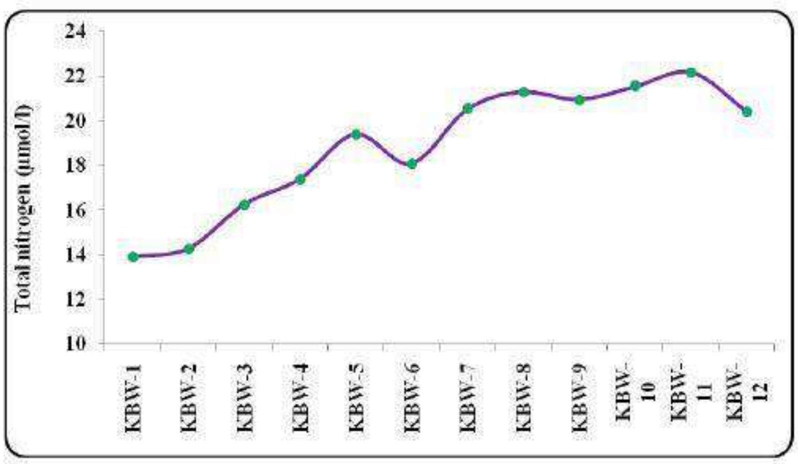


Fig. 12. Total nitrogen values recorded at various stations of Kaluveli backwaters

Ammonical Nitrogen

The ammonia concentration varied from 0.15 to 0.24µmol/l. The maximum concentration (0.24µmol/l) was recorded at KBW-7 and minimum (0.15µmol/l) at KBW-1 (Fig. 13).

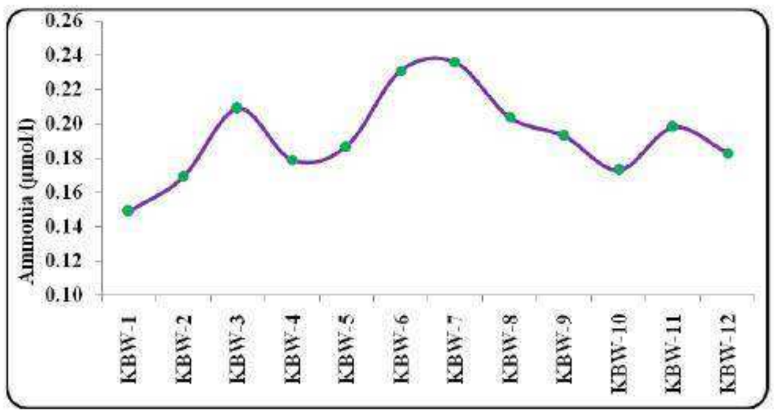


Fig. 13. Ammonical nitrogen concentration recorded at various stations of Kaluveli backwaters

Inorganic Phosphate

The inorganic phosphate values ranged between 0.48 and 1.09µmol/l with maximum at KBW-7 and minimum at KBW-2 (Fig. 14).

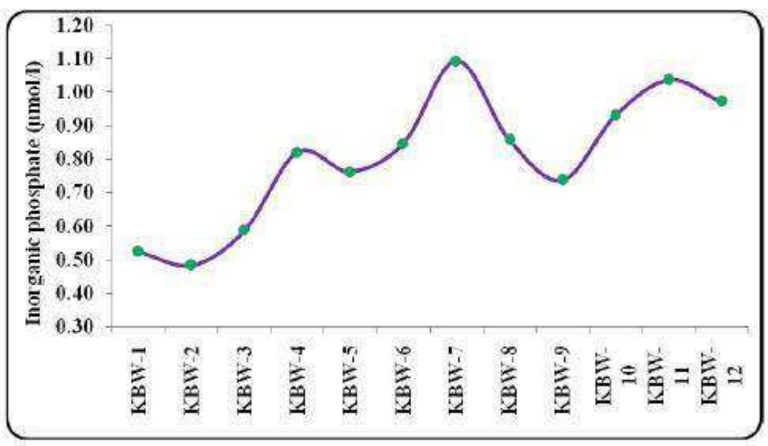


Fig. 14. Inorganic phosphate concentration recorded at various stations of Kaluveli backwaters

Total Phosphorus

The Total phosphorous values ranged from 1.75 to 3.04µmol/l with minimum value at KBW-2 and the maximum value at KBW-11 (Fig. 15).

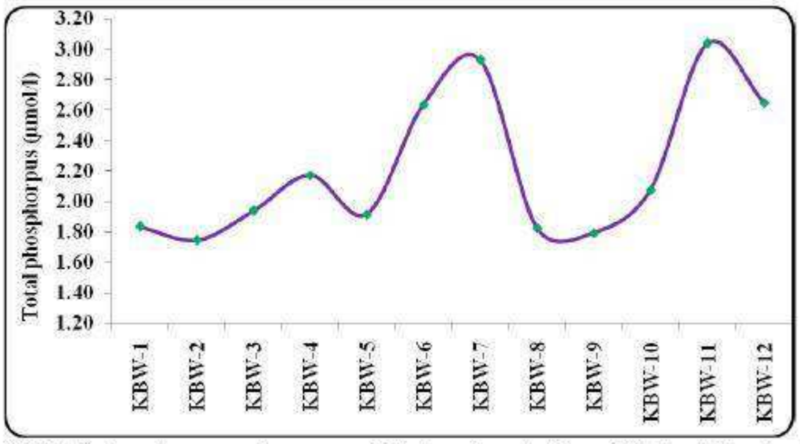


Fig. 15.Total phosphorous values recorded at various stations of Kaluveli backwaters

Reactive Silicate

The silicate values ranged between 40.82 and 52.69µmol/l. The minimum and the maximum values were recorded at KBW-4 and KBW-9 respectively (Fig. 16).

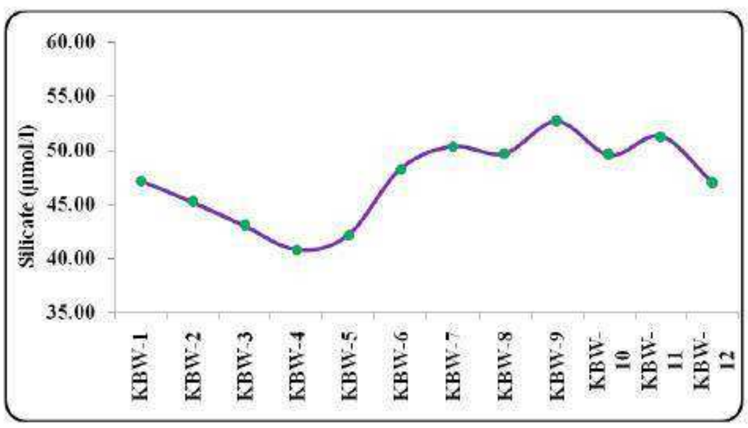


Fig. 16. Reactive silicate level recorded at various stations of Kaluveli backwaters

Particulate organic Carbon

The particulate organic carbon level ranged between 75.34 and 118.09µgC/l with minimum (75.34µgC/l) at KBW-1 and maximum (118.09µgC/l) at KBW-6 (Fig. 17).

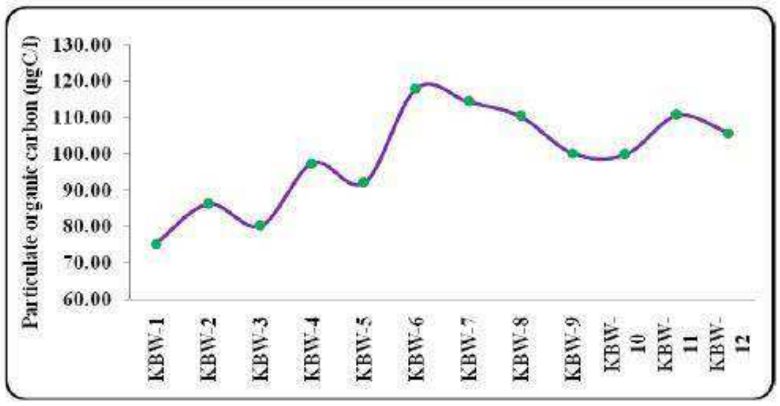


Fig. 17. Particulate organic carbon level recorded at various stations of Kaluveli backwaters

Petroleum hydrocarbons

PHC level in water fluctuated from 0.183 and 0.305µg/l. The maximum was recorded at KBW-1 and the minimum was recorded at KBW-9 (Fig. 18).

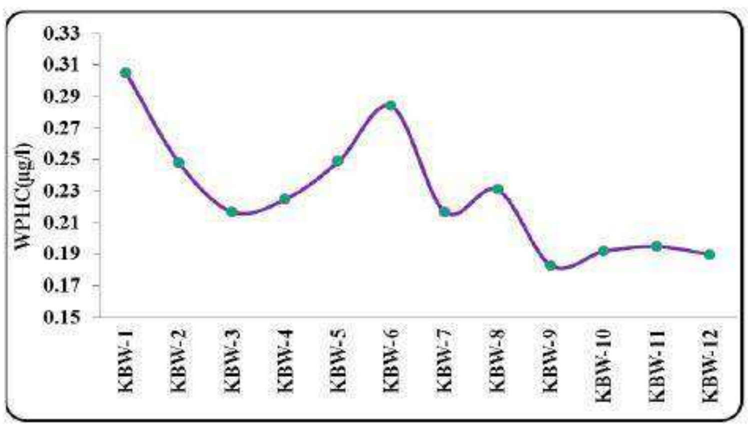


Fig. 18. Petroleum hydrocarbons concentration recorded at various stations of Kaluveli backwaters

Heavy Metals in water

Iron

The iron level varied from 8.23 to 9.35µg/L (Fig. 19). The maximum was recorded at KBW-10 and the minimum was recorded at KBW-1.

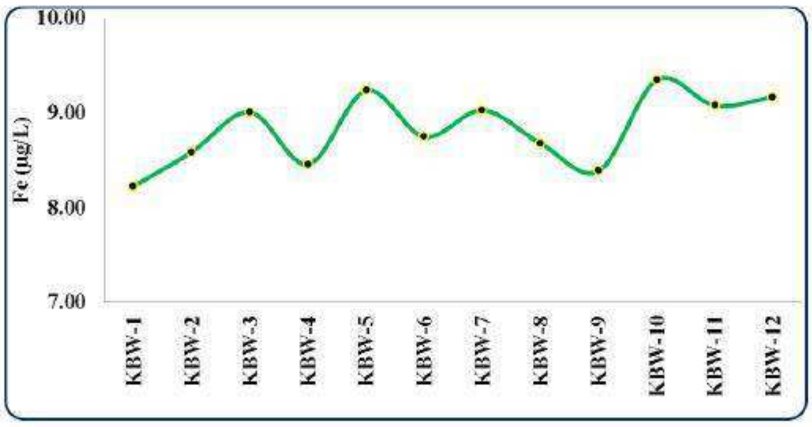


Fig. 19. Iron level recorded at various stations of Kaluveli backwaters

Zinc

The zinc level varied from 12.28 to 13.21µg/L (Fig. 20). The maximum was recorded at KBW-9 and the minimum was recorded at KBW-1.

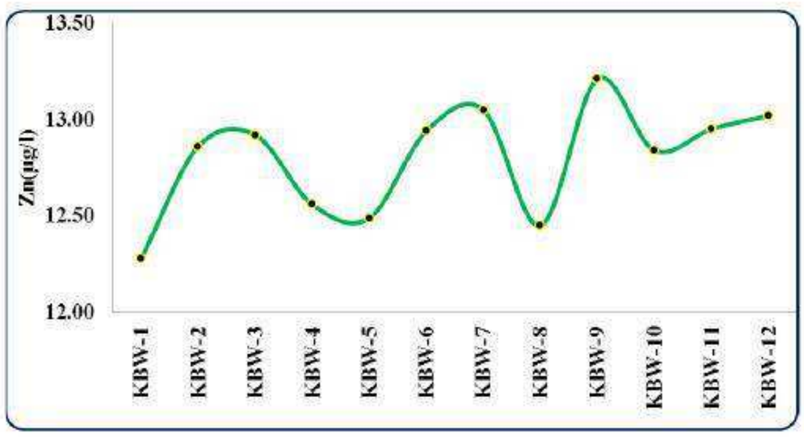


Fig. 20. Zinc level recorded at various stations of Kaluveli backwaters

Manganese

The Manganese concentration varied from 19.83 to 21.48µg/L (Fig. 21). The maximum was recorded at KBW-7 and the minimum was recorded at KBW-1.

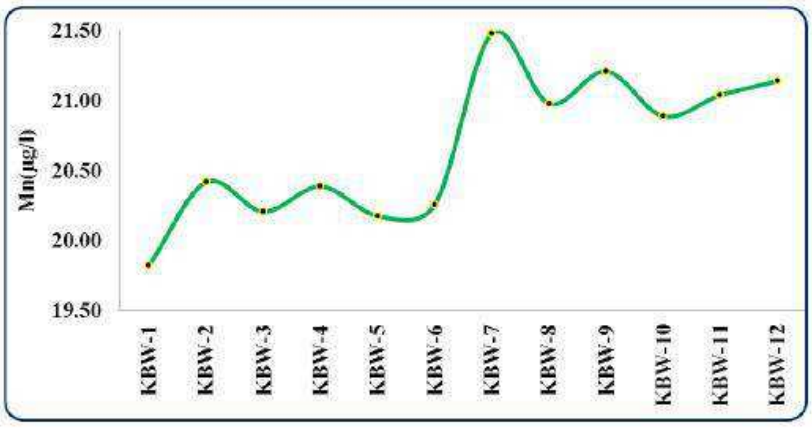


Fig. 21. Manganese concentration recorded at various stations of Kaluveli backwaters

Cadmium

The Cadmium concentration varied from 1.42 to 1.84µg/L (Fig. 22). The maximum was recorded at KBW-9 and the minimum was recorded at KBW-3.

Fig. 22. Cadmium concentration recorded at various stations of Kaluveli backwaters

Nickel

The Nickel level varied from 1.21 to 1.65µg/L (Fig. 23). The maximum level was recorded at KBW-9 and the minimum was recorded at KBW-2.

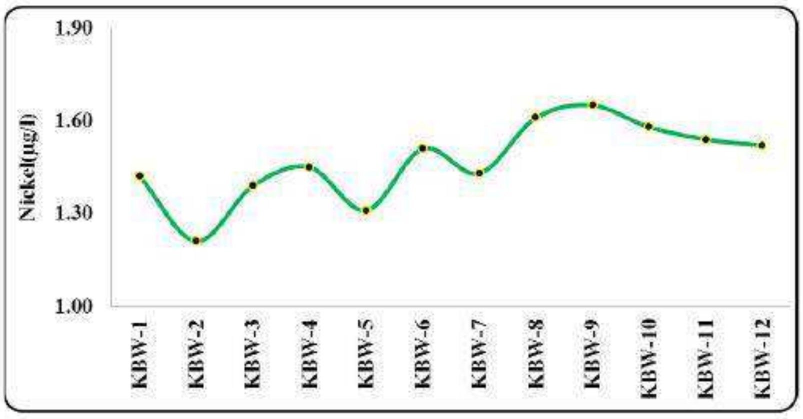


Fig. 23. Nickel level recorded at various stations of Kaluveli backwaters

Chromium

The chromium level varied from 1.01 to 1.43µg/L (Fig. 24). The maximum value was recorded at KBW-9 and the minimum was recorded at KBW-3.

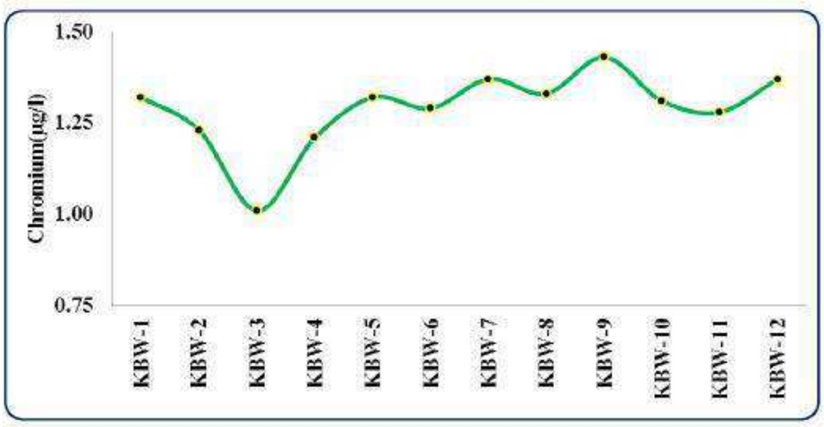


Fig. 24. Chromium level recorded at various stations at Kaluveli backwaters

Lead

The Lead concentration ranged from 1.08 to 1.49µg/L (Fig. 25) with maximum value was recorded at KBW-10 and the minimum was recorded at KBW-2 during this survey

Fig. 25. Lead concentration recorded at various stations of Kaluveli backwaters

Copper

The copper concentration varied from 2.18 to 2.58µg/L (Fig. 26). The maximum was recorded at KBW-11 and the minimum was recorded at KBW-3 during this survey

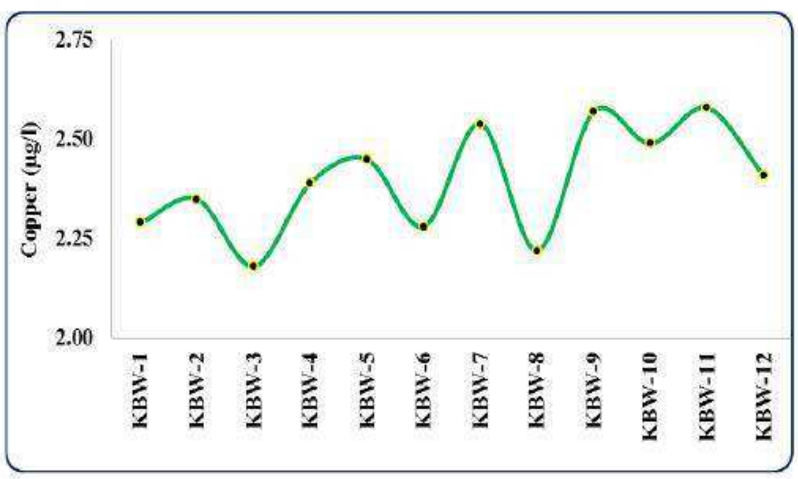


Fig. 26. Copper concentration recorded at various stations of Kaluveli backwaters

Mercury

The mercury level varied from 0.49 to 0.82µg/L (Fig. 27). The maximum value was recorded at KBW-9 and the minimum was recorded at KBW-4 during this survey.

Fig. 27. Mercury level recorded at various stations at Kaluveli backwaters

Sediment Characteristics

Sediment pH

The maximum value (8.29) of soil pH was recorded at KBW-2 and minimum of 7.76 at KBW-11 (Fig. 28).

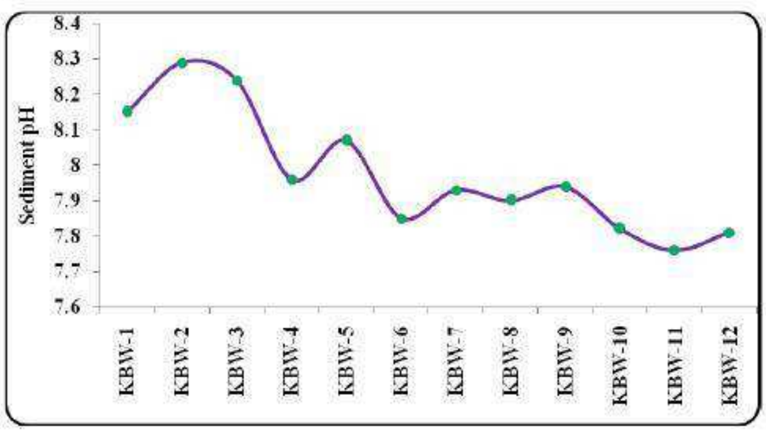


Fig. 28. Soil pH values recorded at various stations of Kaluveli backwaters

Soil Texture

The sand content varied from 3.5 to 35.78% with maximum value at KBW-1 and the minimum at KBW-8; maximum Silt content (53.65%) was found at KBW-3 and minimum (32.86%) at KBW-6 and the maximum Clay content (62.86%) was found at KBW-6 and minimum (17.80%) at KBW-1 (Fig. 29).

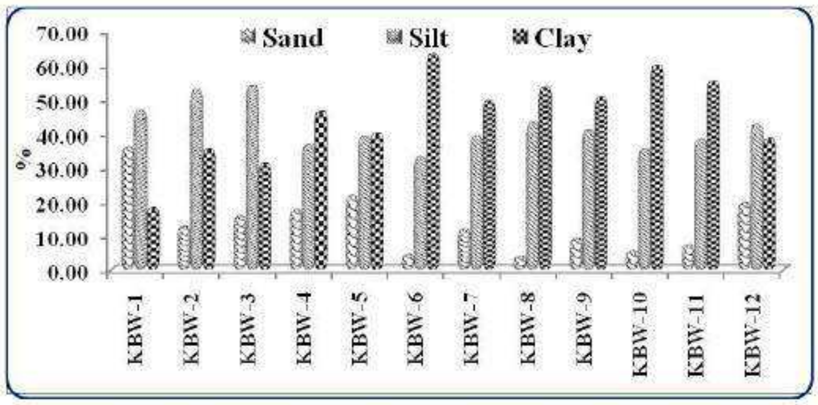


Fig. 29. Variations in soil texture values recorded in various stations of Kaluveli backwaters

Total organic Carbon

The total organic carbon ranged between 4.8 and 6.6mgC/g. The maximum level (6.6mgC/g) was found at KBW-6 and minimum (4.8mgC/g) at KBW-1 (Fig. 30).

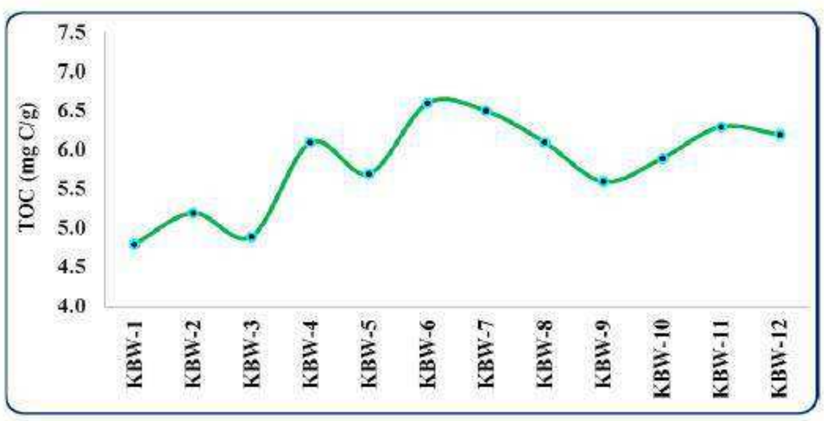


Fig. 30. Total organic carbon values recorded in various stations of Kaluveli backwaters

Sediment PHC

The Sediment PHC level varied from 0.233 to 0.405µg/g (Fig. 31). The maximum level was recorded at KBW-1 and the minimum was recorded at KBW-9 during this survey

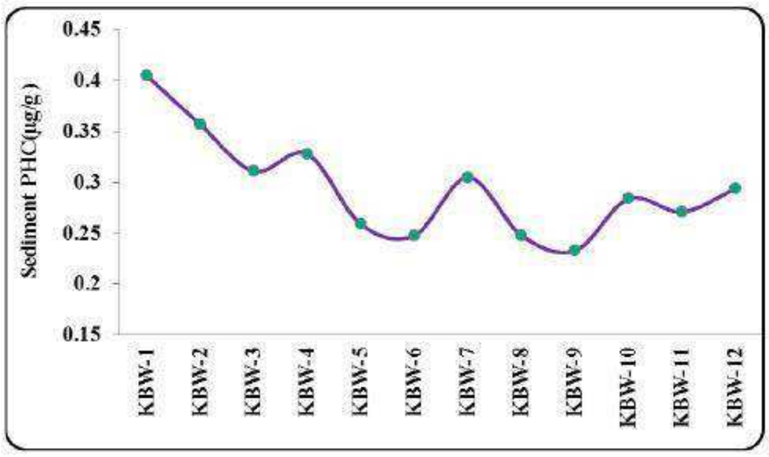


Fig. 31. Sediment PHC level recorded at various stations at Kaluveli backwaters

Heavy Metals in sediments

Iron

The Iron level varied from 1068.5 to 1762.4µg/g (Fig. 32). The maximum was recorded at KBW-11 and the minimum was recorded at KBW-1.

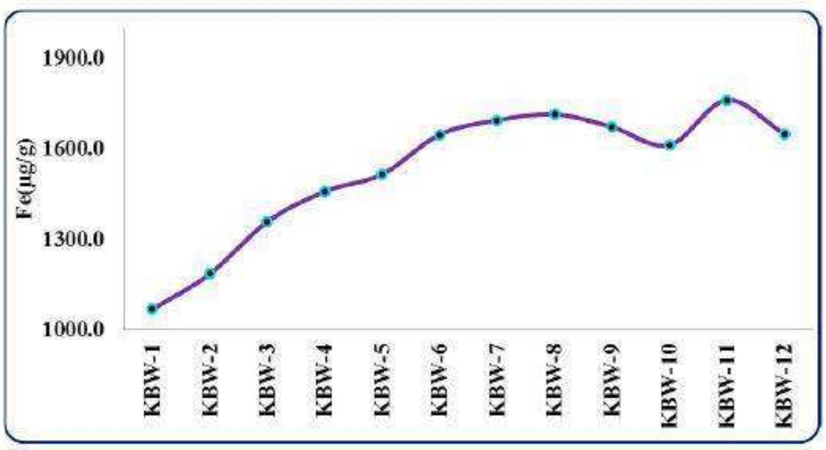


Fig. 32. Iron level recorded in various stations of Kaluveli backwaters

Zinc

Zinc concentration varied from 10.7 to 16.5µg/g (Fig. 33). The maximum level was recorded at KBW-10 and the minimum was recorded at KBW-1.

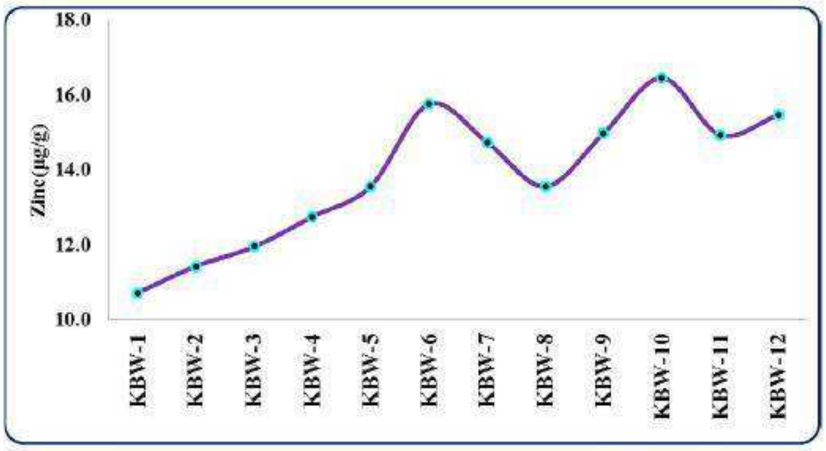


Fig. 33. Zinc concentration recorded at various stations of Kaluveli backwaters

Manganese

The Manganese level varied from 41.4 to 49.9µg/g (Fig. 34). The maximum level was recorded at KBW-8 and the minimum was recorded at KBW-1.

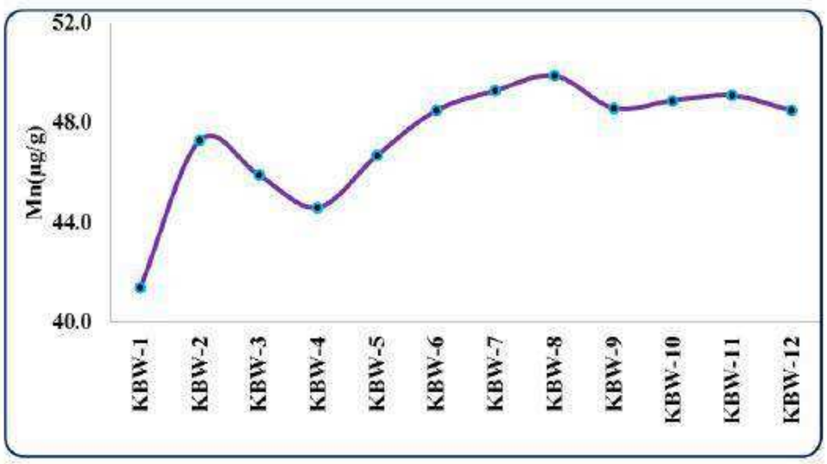


Fig. 34. Manganese level recorded at various stations of Kaluveli backwaters

Cadmium

The Cadmium level varied from 5.33 to 6.92μg/g (Fig. 35). The maximum level was recorded at KBW-10 and the minimum was recorded at KBW-3.

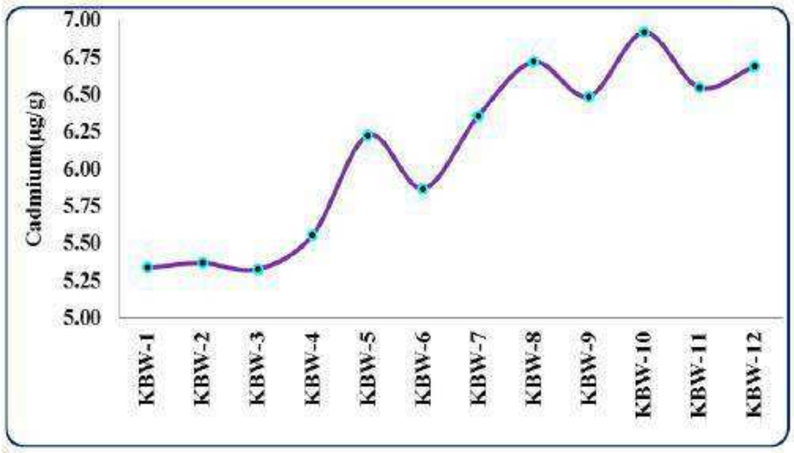


Fig. 35. Cadmium level recorded at various stations of Kaluveli backwaters

Nickel

The nickel concentration varied from 8.54 to 9.75μg/g (Fig. 36). The maximum was recorded at KBW-8 and the minimum was recorded at KBW-2.

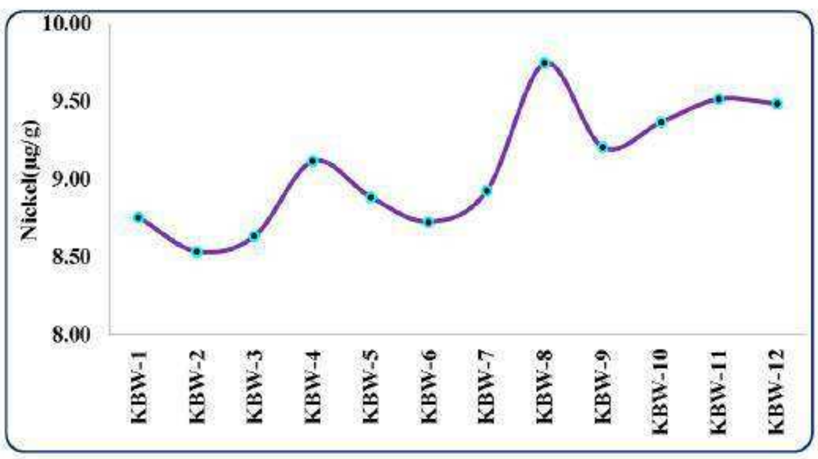


Fig. 36. Nickel concentration recorded at various stations of Kaluveli backwaters

Chromium

The Chromium level varied from 4.12 to 5.89μg/g (Fig. 37) with the maximum was recorded at KBW-9 and the minimum was recorded at KBW-2.

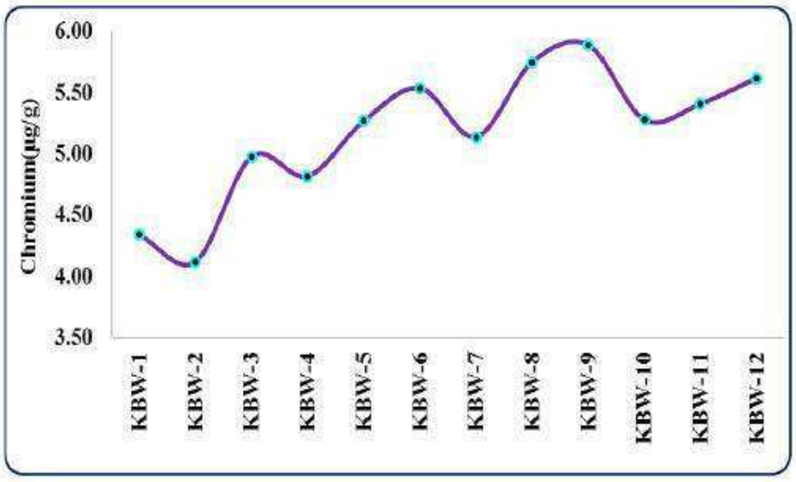


Fig. 37. Chromium level recorded at various stations of Kaluveli backwaters

Lead

The lead concentration varied from 5.15 to 6.35μg/g (Fig. 38). The maximum value was recorded at KBW-8 and the minimum was recorded at KBW-3.

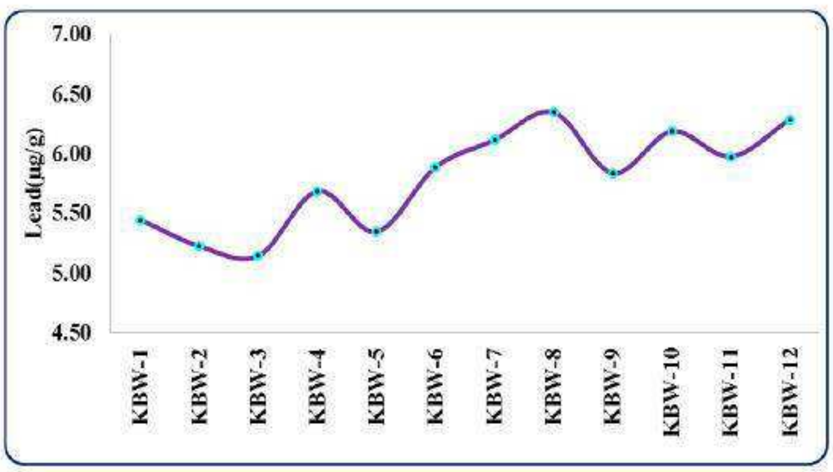


Fig. 38. Lead concentration recorded in various stations of Kaluveli backwaters

Copper

The copper level varied from 11.17 to 13.04µg/g (Fig. 39). The maximum value was recorded at KBW-9 and the minimum was recorded at KBW-3.

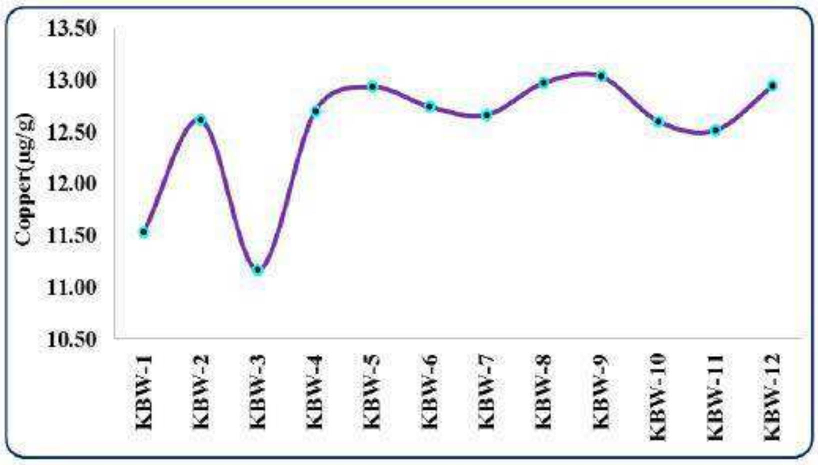


Fig. 39. Copper level recorded in various stations of Kaluveli backwaters

Mercury

The mercury concentration varied from 0.39 to 0.75µg/g (Fig. 40). The maximum was recorded at KBW-10 and the minimum was recorded at KBW-2.

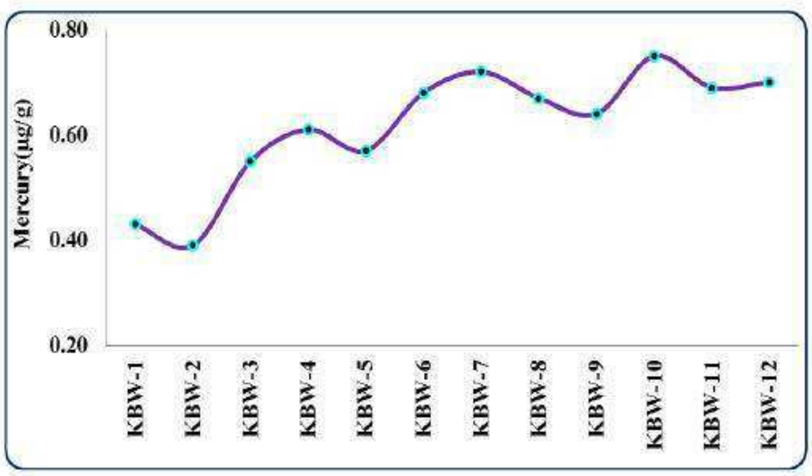


Fig. 40. Mercury concentration recorded in various stations of Kaluveli backwaters

Principle component analysis

The data on physico-chemical parameters collected in water samples were subjected to Principle component analysis to set a well-defined relation between the environmental parameters against the surveyed stations (Fig. 41). The PCA plot drawn indicated that water parameters such as Temperature, Depth, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO_2, NO_3, NH_3, TN, TP, IP, SIO_4, POC, W.PHC, Cu, TOC, sand and Cr had significant correlation with the surveyed stations. Looking at the nature of correlation, the parameters such as Temperature, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO2, NO3, TN, TP, SIO4, POC, IP, PHC, Cu, TOC and TSS got correlated with stations KBW-2, KBW-3, KBW-4, KBW-5 and KBW-1 while the rest of the parameters showed strong correlation with stations KBW-9, KBW-10, KBW-11, KBW-12, KBW-8 and KBW-7.

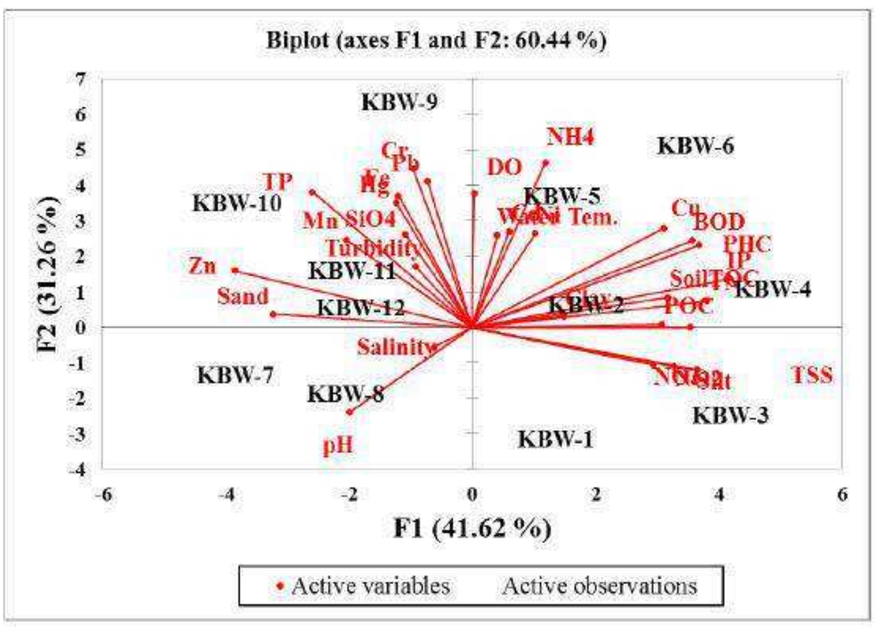


Fig. 41. Principal Component Analysis plot drawn for the correlation between various environmental variables and stations of Kaluveli backwaters

4.3. MICROBIOLOGY

Water sample

The total viable count in water samples ranged from $20x10^4$ to $38x10^3$ CFU/ml. The maximum count was found at KBW-10 and the minimum count was found at KBW-4. The Total coliform count in the samples varied from $21x10^3$ to $07x10^4$ CFU/ml with the high colony count at KBW-12 and the low count at KBW-2. The *E. coli* count ranged from $10x10^2$ to $25x10^2$ CFU/ml with a maximum value at KBW-8 and the minimum value at KBW-3. The *Faecal coliform* was found to vary from $12x10^3$ to $30x10^3$ CFU/ml with higher value at KBW-9 and the lower value at KBW-5. The *Streptococcus faecalis* count ranged from $08x10^2$ to $23x10^3$ CFU/ml. The higher values were recorded at KBW -12 and the lower values were recorded at KBW-1. The *Shigella* count varied from $05x10^3$ to $17x10^3$ CFU/ml with a higher value at KBW-6 and the lower value at KBW-9. The *Pseudomonas aeurginosa* count ranged from $06x10^3$ to $22x10^3$ CFU/ml with maximum value at KBW-12 and the minimum value at KBW-5. The *Salmonella* colony count varied from $07x10^3$ to $22x10^2$ CFU/ml with the higher value at KBW-10 and the lower value at KBW-7. *Vibrio parahaemolyticus* colony count varied from $07x10^2$ to $25x10^2$ CFU/ml with the maximum value at KBW-12 and minimum value at KBW-1. The *Vibrio cholera* colony count was found to fluctuate from $05x10^3$ to $23x10^2$ CFU/ml. The higher colony count was observed at KBW-8 and the lower count was recorded at KBW-3 (Table 1).

Sediment sample

With respect to sediment samples, the total viable count in sediment samples ranged from $23x10^4$ to $68x10^4$ CFU/g. The maximum was found at KBW-8 and the minimum value was found at KBW-3. The Total coli form count in the samples varied from $06x10^4$ to $25x10^3$ CFU/g with the higher colony count at KBW-11 and the lower count at KBW-1. The *E. coli* count ranged from $31x10^4$ to $12x10^4$ CFU/g with the higher value at KBW-10 and the lower value at KBW-5. The *Faecal coliform* count was found to vary from $10x10^5$ to $36x10^4$ CFU/g with the higher value at KBW-6 and the lower value at KBW-1. The *Streptococcus faecalis* count ranged from $26x10^5$ to $07x10^5$ CFU/g. The higher value was recorded at KBW-11 and the lower value was recorded at KBW-5 and KBW-7. The *Shigella* counts varied from $08x10^5$ to $28x10^5$ CFU/g with the higher value at KBW-11 and lower value at KBW-7. *Pseudomonas aeurginosa* counts ranged from $05x10^4$ to $21x10^5$ CFU/g with the maximum at KBW-9 and the minimum at KBW-2. *Salmonella* colony counts varied from $05x10^4$ to $25x10^3$ CFU/g with the maximum value at KBW-11 and the minimum value at KBW-1. *Vibrio parahaemolyticus* colony count varied from $07x10^4$ to $27x10^3$ CFU/g. The higher value was found at KBW-11 and the lower value at KBW-5. The other species *Vibrio cholerae* colony was found to range from $05x10^4$ to $26x10^3$CFU/g with the maximum colony count at KBW-12 and the minimum count was observed at KBW-3 (Table 2).

Table.1. Bacterial population recorded in water samples recorded in various stations of Kaluveli backwaters

Sl.No	Station Code	EC	FC	PA	SF	SH	SL	TC	TVC	VC	VP
1	KBW-1	$15x10^{2}$	$18x10^{3}$	$16x10^{3}$	$08x10^{2}$	$10x10^{3}$	$10x10^{3}$	$11x10^{3}$	$33x10^{4}$	$15x10^{2}$	$07x10^{2}$
2	KBW-2	$13x10^{2}$	$20x10^{2}$	$18x10^{3}$	$14x10^{2}$	$10x10^{2}$	$08x10^{3}$	$07x10^{4}$	$24x10^{3}$	$08x10^{2}$	$15x10^{3}$
3	KBW-3	$10x10^{2}$	$14x10^{4}$	$13x10^{3}$	$10x10^{1}$	$07x10^{2}$	$12x10^{2}$	$09x10^{4}$	$33x10^{3}$	$05x10^{3}$	$16x10^{2}$
4	KBW-4	$24x10^{2}$	$17x10^{2}$	$08x10^{3}$	$12x10^{3}$	$13x10^{3}$	$10x10^{3}$	$08x10^{3}$	$20x10^{4}$	$15x10^{2}$	$12x10^{3}$
5	KBW-5	$20x10^{2}$	$12x10^{3}$	$06x10^{3}$	$09x10^{3}$	$10x10^{2}$	$13x10^{2}$	$14x10^{3}$	$36x10^{3}$	$10x10^{3}$	$19x10^{2}$
6	KBW-6	$20x10^{2}$	$13x10^{2}$	$13x10^{3}$	$14x10^{2}$	$17x10^{3}$	$08x10^{3}$	$14x10^{2}$	$28x10^{3}$	$10x10^{2}$	$19x10^{2}$
7	KBW-7	$13x10^{3}$	$26x10^{3}$	$10x10^{2}$	$15x10^{4}$	$13x10^{3}$	$07x10^{3}$	$08x10^{3}$	$36x10^{2}$	$08x10^{2}$	$18x10^{2}$
8	KBW-8	$25x10^{2}$	$20x10^{4}$	$17x10^{4}$	$18x10^{4}$	$08x10^{4}$	$10x10^{2}$	$10x10^{3}$	$33x10^{2}$	$23x10^{2}$	$20x10^{3}$
9	KBW-9	$20x10^{2}$	$30x10^{3}$	$14x10^{4}$	$10x10^{3}$	$05x10^{3}$	$11x10^{4}$	$15x10^{3}$	$24x10^{3}$	$16x10^{3}$	$14x10^{2}$
10	KBW-10	$23x10^{2}$	$18x10^{3}$	$20x10^{3}$	$13x10^{2}$	$13x10^{3}$	$22x10^{2}$	$10x10^{4}$	$38x10^{3}$	$18x10^{2}$	$21x10^{3}$
11	KBW-11	$16x10^{3}$	$19x10^{2}$	$12x10^{3}$	$14x10^{3}$	$10x10^{2}$	$20x10^{2}$	$13x10^{3}$	$24x10^{3}$	$19x10^{3}$	$15x10^{2}$
12	KBW-12	$18x10^{3}$	$20x10^{2}$	$22x10^{3}$	$23x10^{3}$	$10x10^{2}$	$14x10^{3}$	$21x10^{3}$	$29x10^{3}$	$22x10^{3}$	$25x10^{2}$

41

Table.2. Bacterial population recorded in sediment samples collected in various stations of Kaluveli backwaters

Sl. No	Station Code	EC	FC	PA	SF	SH	SL	TC	TVC	VC	VP
1	KBW-1	$13x10^{5}$	$10x10^{5}$	$16x10^{5}$	$09x10^{5}$	$09x10^{4}$	$05x10^{4}$	$06x10^{4}$	$24x10^{3}$	$16x10^{3}$	$22x10^{3}$
2	KBW-2	$13x10^{4}$	$28x10^{4}$	$05x10^{4}$	$13x10^{5}$	$12x10^{5}$	$11x10^{5}$	$18x10^{3}$	$30x10^{3}$	$09x10^{3}$	$11x10^{4}$
3	KBW-3	$18x10^{3}$	$15x10^{3}$	$08x10^{4}$	$16x10^{5}$	$13x10^{5}$	$10x10^{5}$	$10x10^{4}$	$23x10^{4}$	$05x10^{4}$	$18x10^{3}$
4	KBW-4	$15x10^{5}$	$26x10^{5}$	$16x10^{5}$	$10x10^{4}$	$18x10^{4}$	$10x10^{4}$	$16x10^{3}$	$46x10^{3}$	$10x10^{3}$	$10x10^{5}$
5	KBW-5	$12x10^{4}$	$20x10^{4}$	$11x10^{4}$	$07x10^{5}$	$12x10^{5}$	$08x10^{5}$	$13x10^{3}$	$33x10^{3}$	$06x10^{5}$	$07x10^{4}$
6	KBW-6	$18x10^{5}$	$36x10^{4}$	$08x10^{5}$	$09x10^{5}$	$10x10^{4}$	$09x10^{4}$	$24x10^{5}$	$43x10^{4}$	$07x10^{5}$	$09x10^{5}$
7	KBW-7	$17x10^{4}$	$17x10^{4}$	$12x10^{4}$	$07x10^{5}$	$08x10^{5}$	$08x10^{5}$	$08x10^{5}$	$44x10^{4}$	$10x10^{3}$	$15x10^{3}$
8	KBW-8	$26x10^{4}$	$20x10^{4}$	$10x10^{3}$	$22x10^{4}$	$16x10^{5}$	$13x10^{5}$	$13x10^{5}$	$68x10^{4}$	$13x10^{3}$	$21x10^{3}$
9	KBW-9	$20x10^{4}$	$15x10^{4}$	$21x10^{5}$	$15x10^{5}$	$10x10^{5}$	$08x10^{5}$	$08x10^{5}$	$30x10^{4}$	$20x10^{4}$	$24x10^{4}$
10	KBW-10	$31x10^{4}$	$22x10^{4}$	$14x10^{5}$	$10x10^{5}$	$12x10^{5}$	$10x10^{4}$	$13x10^{4}$	$36x10^{4}$	$16x10^{4}$	$20x10^{3}$
11	KBW-11	$20x10^{4}$	$23x10^{4}$	$20x10^{4}$	$26x10^{5}$	$28x10^{5}$	$25x10^{3}$	$25x10^{3}$	$29x10^{4}$	$21x10^{3}$	$27x10^{3}$
12	KBW-12	$26x10^{3}$	$24x10^{3}$	$19x10^{4}$	$18x10^{4}$	$14x10^{4}$	$15x10^{3}$	$17x10^{3}$	$31 x10^{4}$	$26x10^{3}$	$20x10^{4}$

42

4.4 Pigments

Chlorophyll –a (mg/m^3), Phaeopigments (mg/m^3) and Total biomass ($ml/100m^3$)

In the present study, the chlorophyll '*a*' in water sample varied from 0.942 to 2.935 mg/m^3, with maximum at KBW-3 and minimum at KBW-11. The Phaeopigments content varied from 0.925 to 3.075 mg/m^3 with maximum was at KBW-3 and the minimum was observed at KBW-11. The Total biomass values varied from 1.102 to 3.419 $ml/100m^3$, with maximum at KBW-3 and minimum at KBW-11 (Table 4).

Table. 4. Chlorophyll *a*, Phaeopigments and total biomass recorded in Kaluveli backwaters

Station ID	Chlorophyll 'a' (mg/m3)	Phaeopigments (mg/m3)	Total biomass (ml/100m3)
KBW-1	2.004	2.430	2.612
KBW-2	2.178	2.182	2.428
KBW-3	2.935	3.075	3.419
KBW-4	2.119	2.752	2.896
KBW-5	1.385	1.985	2.022
KBW-6	1.627	1.859	2.147
KBW-7	2.119	2.284	2.539
KBW-8	1.850	2.446	2.675
KBW-9	1.631	1.936	2.028
KBW-10	1.624	2.045	2.145
KBW-11	0.942	0.925	1.102
KBW-12	2.036	2.137	2.407

Primary productivity

The primary productivity was measured using the dark and light reaction method. The values ranged from 120.31 to 201.38mgC$m^{-3}d^{-1}$. The maximum value was recorded at KBW-3 and minimum value at KBW-10 (Fig. 42).

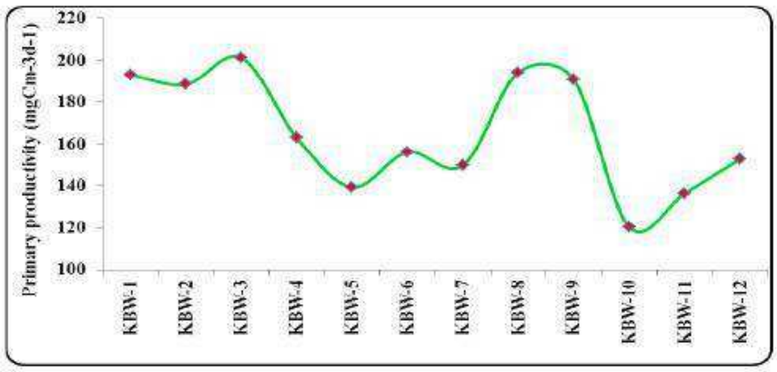


Fig. 42. Primary productivity values recorded at various stations of Kaluveli backwaters

4.5. Biological entities

4.5.1 Phytoplankton

In the present study, as many as 54 phytoplankton species belonging to thirteen groups namely Bacillariaceae, Naviculoideae, Bellerocheaceae, Biddulphoidae, Chaetocereae, Coscinodisceae, Eucampiinae, Asterionellaceae, Soleniceae, Triceratiinae, Ceratiaceae, Peridiniaceae, Prorocentraceae, Dinophysiaceae and Blue Green algae were recorded. Of these, Coscinodisceae were found to be the dominant group with 8 species. Chaetocereae and Naviculoideae formed next dominant groups with 6 species and Soleniceae with 5 species, Triceratiinae and Blue Green algae with 4 species each. Dinophysiaceae, Ceratiaceae and Bacillariaceae with 3 species each and Bellerocheaceae, Biddulphoidae, Eucampiinae, Asterionellaceae, Peridiniaceae and Prorocentraceae came last in the order with 2 species each.

Among the Coscinodisceae, *Coscinodiscus centralis, C. gigas, C. granii, C. radiates, Lauderia borealis* and *Skeletonema costatum* were found to be the commonly occurring species in the samples collected in various stations. In Chaetocereae, species such as *Bacteriastrum comosum, Chaetoceros affinis, C. currvisetus* and *C. diversus* were recorded commonly from the surveyed stations. Similarly, species such as *Bacillaria paradoxa, Leptocylindrus danicus, Rhizosolenia alata, Ditylum brightwelli, Odontella mobiliensis, O. sinensis, Anabaena* sp., *Trichodesmium* sp., *Microcystis* sp. and *Oscillatoria* sp.. in Soleniceae, Triceratiinae and Blue Green algae and *Nitzschia longissima, N. seriata, Bellerochea malleus, Biddulphia obtuse, Eucampia zoodiacus, Dinophysis puncata, D. caudate, Prorocentrum micans, Ceratium furca, C. macroceros* and *Astrionella glacialis* in Dinophysiaceae, Ceratiaceae, Bacillariaceae, Bellerocheaceae, Biddulphoidae, Eucampiinae, Asterionellaceae, Peridiniaceae and Prorocentraceae showed consistency in their occurrence in the samples collected in various surveyed stations.

Population density

Density of phytoplankton varied from 8384 to 14674 Cells/l with maximum was at KBW-1 and minimum at KBW-11 (Fig. 43).

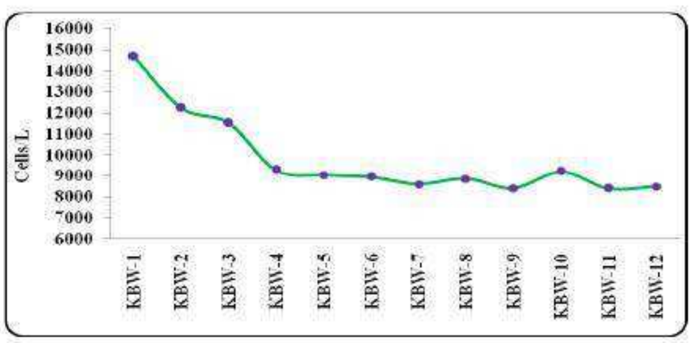


Fig. 43. Population density of Phytoplankton recorded in various stations of Kaluveli backwaters

Percentage composition of phytoplankton

When the results of percentage composition of phytoplankton were looked at, Coscinodisceae constituted the maximum with 16% of the total followed by Chaetocereae with 11% and Naviculoideae with 10%, Soleniae with 8%, Triceratiinae and Blue green algae with 7% each, Ceratiaceae with 6%, Bacillariaceae Biddulphoidae, Asterionellaceae and Dinophysiaceae with 5% each, Bellerocheaceae, Prorocentraceae and Peridiniaceae with 4% each and Eucampiinae contributed to 3% to the total percentage composition of community (Fig. 44).

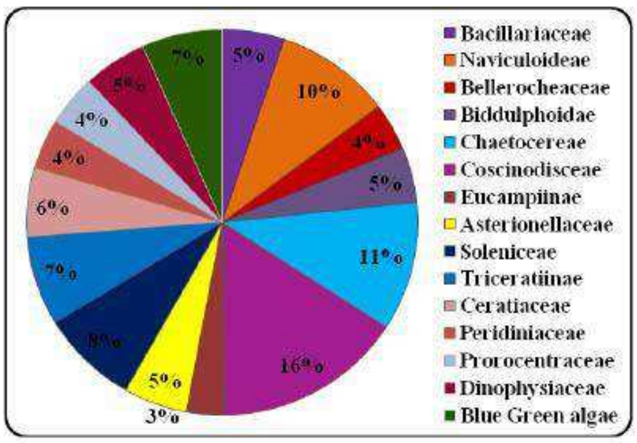


Fig. 44. Percentage composition of Phytoplankton recorded in various stations of Kaluveli backwaters

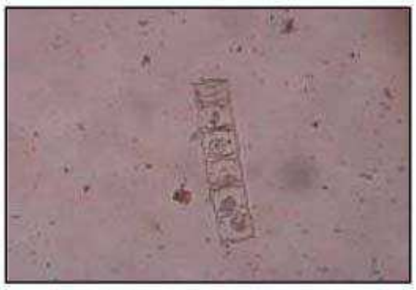
Diversity indices

The phytoplankton species diversity (H') varied from 2.894 to 3.867 with maximum value was recorded at KBW-2 and minimum at KBW-10. The species richness (d) ranged between 4.768 and 6.421 with maximum at KBW-12 and minimum value was recorded at KBW-1. The species evenness varied from 0.832 to 0.926 with the maximum value was recorded at KBW-3 and minimum at KBW-11 (Table - 5).

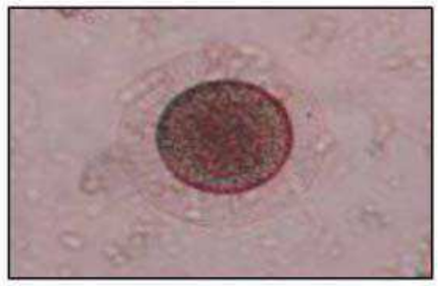
Table 5. Diversity indices, *a*-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') calculated for Phytoplankton in Kaluveli backwaters

Station ID	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.364	4.768	0.919
KBW-2	3.867	5.918	0.904
KBW-3	3.816	5.560	0.926
KBW-4	3.174	5.363	0.901
KBW-5	3.026	4.830	0.832
KBW-6	3.162	5.495	0.877
KBW-7	3.426	5.188	0.901
KBW-8	2.918	5.171	0.862
KBW-9	3.352	4.864	0.892
KBW-10	2.894	4.979	0.851
KBW-11	2.946	4.981	0.832
KBW-12	2.963	6.421	0.836

PLATE-I: COMMON PHYTOPLANKTON RECORDED

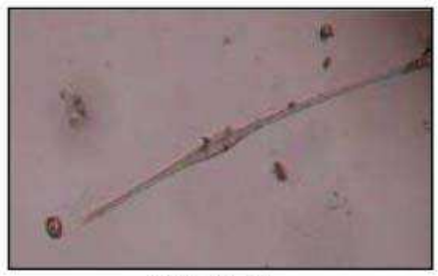


Bellerochea malleus

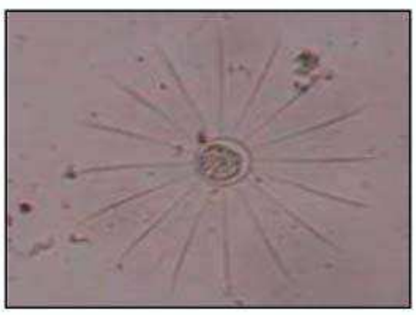


Planktonella sol

***Pluerosigma* sp.**



***Nitzschia* sp.**



***Bacteriostrum* sp.**

***Asterionella* sp.**

4.5.2 Zooplankton

During the survey, a total of 50 species belonging to 6 groups of macro zooplankton namely, Calanoid copepods, Cyclopoid copepods, Harpacticoid copepods, Ciliates, Rotatoria and Other Crustacean forms, and 5 groups of micro zooplankton namely, Mollusca, Larvacean, Pteropoda, Foraminifera and Annelida were recorded. In macro zooplankton, Calanoid copepod was found to be the dominant group with 14 species. Ciliates came as next dominant group with 8 species and Cyclopoid copepod with 7 species. Harpacticoid and Other Crustacean forms came next in the order with 5 species each. Among microzooplankton, Larvacean and Foraminifera were recorded with 3 species each and Mollusca, Rotatoria with 2 species each and Annelida and Pteropoda with 1 species each to the total zooplankton abundance.

Of the various taxa, the species namely *Eutintinnus tennuis, Favella brevism, F. philipiensis, Rhabdonella lohmani, Tintinnopsis tocantinensis, T. tubulosa, T. butzschi, Acartia centrura, A. danae, Acrocalanus gibber, Paracalanus parvus, Pseudodiaptomus aurivilli, Temora tubinata* and *Tortanuus barbatus* were found to be common during this survey. Similarly Bivalve veliger, Gastropod veliger, *Globigernia bulloides, G opima* and Polychaete larvae among micro zooplankton, showed consistency in their occurrence in the samples collected in various stations.

Population density

The zooplankton density varied from 6,556 to 7,068 Nos/m^3 with maximum at KBW-3 and minimum at KBW-11 (Fig. 45).

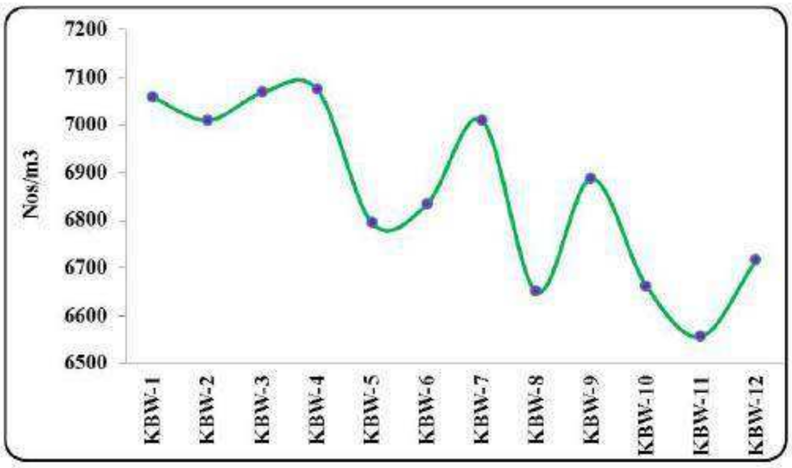


Fig. 45. Population density of zooplankton recorded in various stations of Kaluveli backwaters

Percentage composition

Calanoid copepods emerged as the dominant group by constituting 27%, followed by Ciliates with 16%, Cyclopoid copepods with 13%, Harpacticoid copepods with 11%, Other Crustacean forms with 9%, Larvacean and Foraminifera with 6% each and Mollusca and Rotatoria with 4% each and Annelida, Pteropoda with 2% each to the total (Fig. 46).

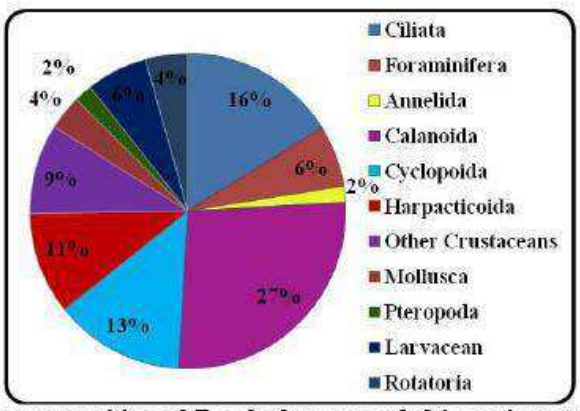


Fig. 46. Percentage composition of Zooplankton recorded in various stations of Kaluveli backwaters

Diversity Indices

As done for phytoplankton, the zooplankton species diversity (H') varied from 2.528 to 3.736 with maximum in KBW-2 and minimum in KBW-9. The species richness (d) ranged between 4.639 and 6.683 with maximum in KBW-6 and minimum in KBW-3. The species evenness varied from 0.764 to 0.927 with the maximum in KBW-2 and minimum in KBW-10 (Table 6).

Table 6. Diversity indices, *a*-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') calculated for zooplankton in Kaluveli backwaters

Station ID	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.510	5.258	0.834
KBW-2	3.736	4.739	0.927
KBW-3	3.384	4.639	0.895
KBW-4	3.288	4.925	0.884
KBW-5	3.492	5.017	0.821
KBW-6	3.110	6.683	0.816
KBW-7	2.899	5.641	0.897
KBW-8	2.703	6.419	0.807
KBW-9	2.528	5.652	0.784
KBW-10	2.793	5.013	0.764
KBW-11	2.604	5.335	0.838
KBW-12	2.785	5.977	0.809

Cluster analysis

The abundance data of phytoplankton and zooplankton were amalgamated and subjected to classification and ordination methods. The resulting dendrogram revealed the groupings of stations separately. The results revealed that stations near to the coastal zone KBW-1, KBW-3 and KBW-2 formed a separate cluster based on species composition and abundance. The remaining stations within the backwaters namely KBW-7, KBW-8, KBW-4, KBW-9 and KBW-11, KBW-6, KBW-12, KBW-5 and KBW-10 formed separate clusters (Fig. 47). This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.07), which is overlying on the top-right corner of the MDS plot, was also found to be low signifying the good ordination pattern of the samples (Fig. 48).

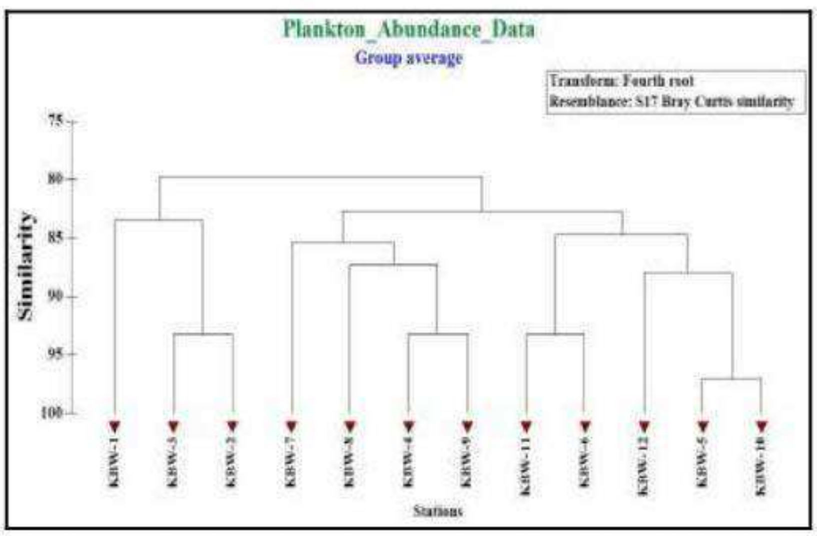


Fig. 47. Dendrogram for the Plankton abundance data collected from Kaluveli backwaters

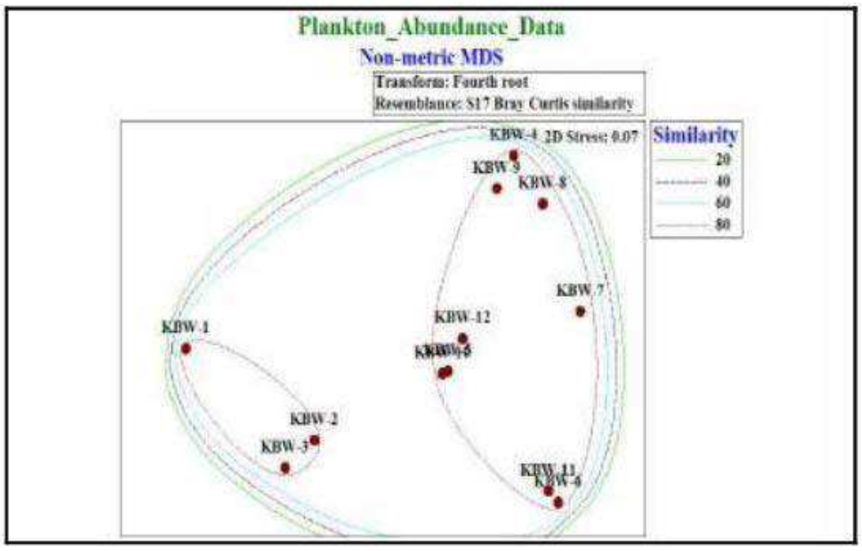


Fig. 48. MDS drawn for the Plankton abundance recorded in various stations of Kaluveli backwaters

5.16. BIO-ENV (Biota-Environment matching)

The BIO-ENV procedure was adopted to measure the agreement between the rank correlations of the biological (Bray-Curtis similarity) and environmental (Euclidean distance) matrices. To achieve this, twelve environmental variables (Primary productivity, Total nitrogen, Nitrite, Nitrate, Dissolved oxygen, Salinity, Chlorophyll 'a', Silicate, Inorganic phosphate, Total phosphate, ammonia, pH and Temperature) were allowed to match the biota. The results of best combinations are given in Table 7.

In this case, the Dissolved Oxygen, Salinity, Primary productivity, Total biomass, Chlorophyll 'a', Total Nitrogen, Silicate and Total phosphate were featured as the major variables explaining the best match ($\rho\omega$= 0.964) with plankton (both phytoplankton and zooplankton) distributions. The other parameters such as Dissolved Oxygen, Temperature, Inorganic phosphate, Primary productivity, Silicate, Chlorophyll 'a' and Total Nitrogen also got manifested in the next best variable combinations in determining the plankton distribution in Kaluveli backwaters.

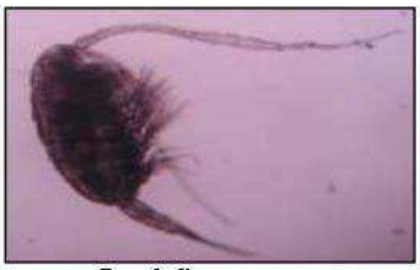
Table-7. Harmonic rank correlations (ρω) between plankton (both phytoplankton and zooplankton) abundance against environmental variables in Kaluveli backwaters

S. No.	No. of variables	Best variable combinations	Correlation (ρω)
1.	8	Dissolved Oxygen - Salinity - Primary productivity – Total biomass - Chlorophyll 'a' - Total Nitrogen - Silicate – Total phosphate	0.958
2.	7	Dissolved Oxygen - Temperature - Inorganic phosphate - Primary productivity - Silicate - Chlorophyll 'a' - Total Nitrogen	0.926
3.	6	Salinity – Inorganic phosphate - Total Nitrogen – Primary productivity – Silicate - Dissolved oxygen	0.884
4.	5	Dissolved oxygen - Salinity - Chlorophyll 'a'- Nitrite - Total biomass	0.852
5.	4	Dissolved Oxygen - Silicate –Primary productivity – Chlorophyll 'a'	0.791

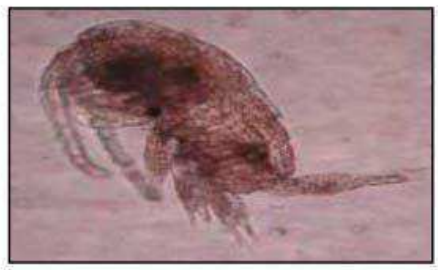
PLATE-II COMMON ZOOPLANKTON RECORDED

Brachionus **sp.**

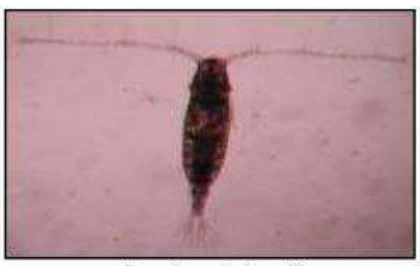
Paracalanus parvus



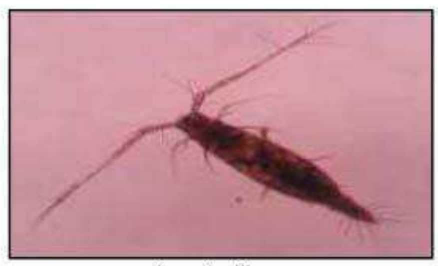
Pseudodiaptomus **sp.**



Acrocalanus **sp.**



Acartia spinicauda

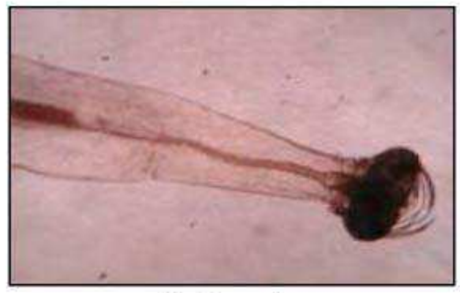


Acartia danae

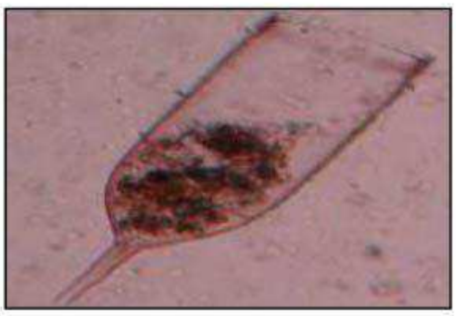
Corycaeus **sp.**

Microsetella **sp.**

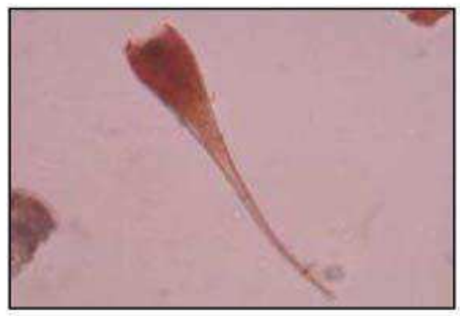
Euterpina acutifrons



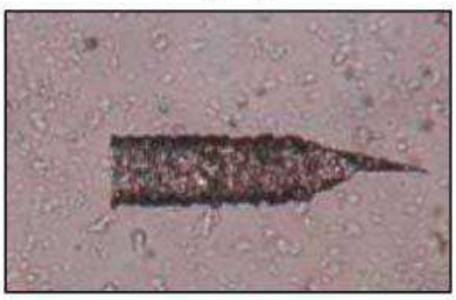
Sagitta enflata



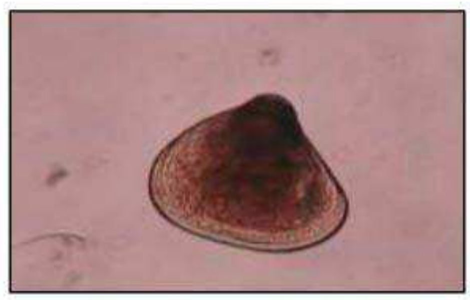
Favella philippinesis



Rhabdonella sp.



Tintinnopsis cylindrica



Bivalve veliger

4.6. BENTHOS

4.6.1. Macro-benthos

During the present investigation, five groups of benthic organisms namely polychaetes, bivalves, gastropods, amphipods and group "others" were recorded in Kaluveli backwaters. Among them, polychaetes constituted the dominant group followed by bivalves, gastropods, amphipods and group 'others'. Altogether, 37 species of macro fauna were recorded from surveyed stations. Of these, polychaetes topped the list with 21 species. Bivalves were found to be the next dominant group in the order of abundance with 9 species. Gastropods and group "others" came next in the order with 4 and 2 species respectively of the total benthic organisms collected. Amphipod came last in the order with one species during the present study.

Among the polychaetes, *Cossura coasta, Ancistrosyllis parva*, *Nephtys* sp., *N. capensis*, *Dendronereis* sp., *Nereis* sp. and *Notomastus* sp. were found to be the most commonly occurring species in the samples collected in Kazhuveli backwaters. Coming to bivalves, *Sunnata meroe, Meretrix Casta, Mactra laevis* and gastropods, *Cerithidea cingulata*, *Natica macrochiensis* and in group "others" crab, fish fry were found to be common species in the present survey respectively.

Population density

The population density varied from 100 to 1900 Nos.m^{-2} with maximum at KBW-2 and minimum at KBW-12 (Fig. 46)

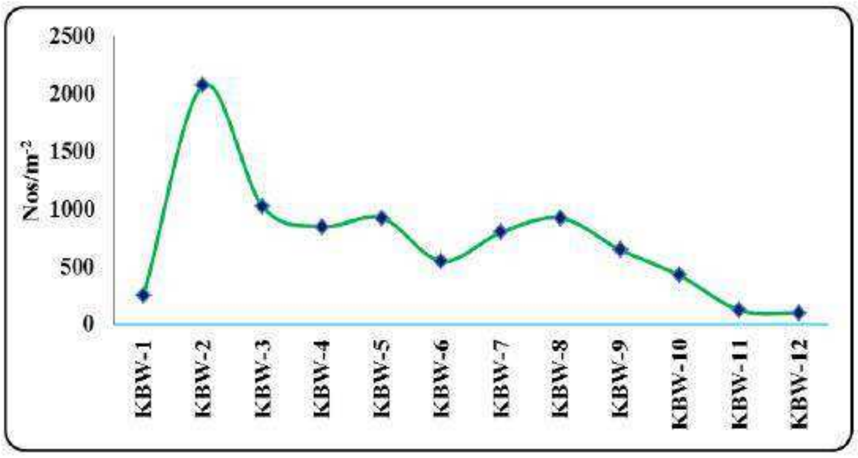


Fig. 46. Population density of macro benthos recorded in various stations of Kaluveli backwaters

Percentage composition

When the results of percentage composition of benthic fauna were viewed, polychaetes constituted the maximum with 57% to the total benthic organisms. Bivalves, gastropods, group "others" and amphipods contributed 24%, 5% and 3% respectively to the benthic samples collected (Fig. 47).

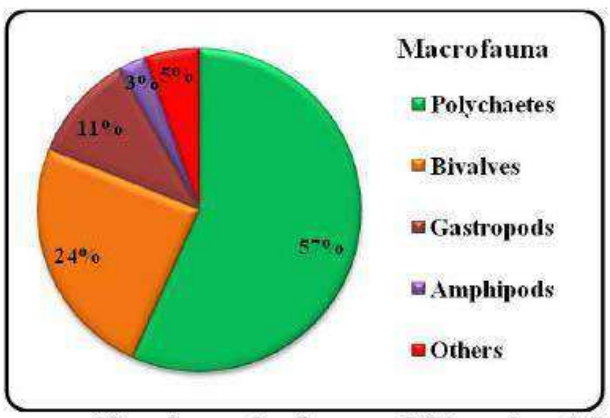


Fig. 47. Percentage composition of macro benthos recorded in various stations of Kaluveli backwaters

Diversity indices

The macrobenthos species diversity (H') varied from 2.47 to 3.83 with maximum in KBW-2 and minimum in KBW-12. The species richness (d) ranged between 4.46 and 6.82 with maximum in KBW-12 and minimum in KBW-2. The species evenness varied from 0.81 to 0.97 with the maximum in KBW-2 and minimum in KBW-12 (Table 6).

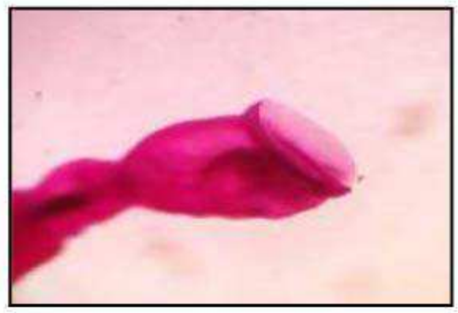
Table. 6. Diversity indices a-Shannon diversity (H'); b-Margalef richness (d) and c-Pielou's evenness (J') for macro-benthos in Kaluveli backwaters

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	3.32	5.63	0.90
KBW-2	3.83	4.65	0.97
KBW-3	2.69	5.40	0.83
KBW-4	2.65	5.04	0.88
KBW-5	3.09	4.46	0.86
KBW-6	3.18	4.59	0.92
KBW-7	3.54	4.95	0.93
KBW-8	2.75	6.03	0.92
KBW-9	3.45	4.71	0.91
KBW-10	3.03	4.87	0.96
KBW-11	2.32	6.82	0.88
KBW-12	2.47	6.34	0.81

PLATE-III COMMON MACRO-BENTHOS

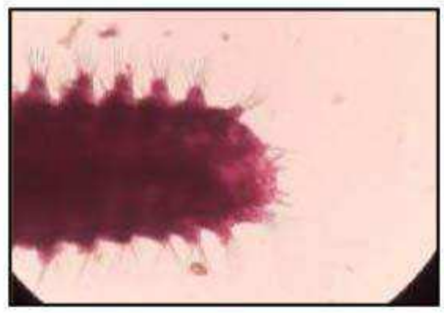
POLYCHAETES

Poecilochaetus serpens

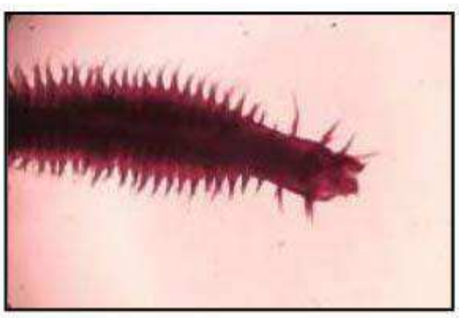


***Clymenura* sp.**

Notomastus aberans



Nephtys dibranchis



Ancistrosyllis parva

***Dendronereis* sp.**

BIVALVES

Meretrix casta

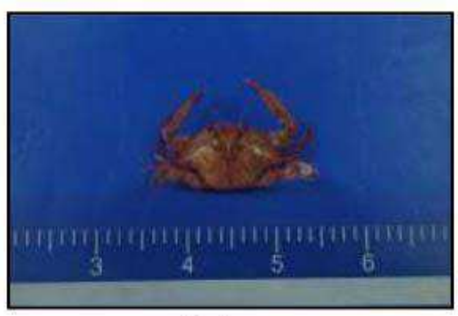
Brachydontes viriablis

Mactra laevis

Donax cuneatus

Gastropods and Others

Cerithidea cingulata



Crab sp.

4.5.2. Meio-benthos:

In the present study, as many as 44 species belonging to four groups of Meio-benthic organisms namely Foraminiferans, Nematodes, Ostracods and Harpacticoids were recorded. Among them, Foraminiferans topped the list with 26 species. Nematodes and Ostracods were found to be the next dominant groups in the order of abundance with 7 species each and Harpacticoids came next with 4 species.

Among the foraminiferans, *Ammodiscus exsertus, Ammonia beccarii, Bolivina punctuate, Elphidium advenum, Globigerina globularis, Quinqueloculina debenayi, Rosalina globularis, S. tuberculata, S. angulosa, S. bradyi* and *Trichohyalus aguayoi* were found commonly in various stations. With respect to nematodes, *Halalaimus filum, Oxystomina clavicauda, Enoplolaimus abnormis,* and *Neocamacolaimus parasiticus* were found to be the common species in the samples collected in various stations. The Ostracods species such as *Basslerites liebaui, Bairdoppilata scaura, Paracytherideis* sp., *Eucythere argus, Microcytherura nigrescens* and *Tanella gracilis* and the Harpacticoids, *Leptastacus mocronyx* and *Canuella perplexa* were found to be common species in the surveyed stations.

Population density

The population density of Meio-benthic fauna varied from 176 to 248Nos10cm^{-2} with maximum was at KBW-2 and minimum at KWB-12 (Fig. 51).

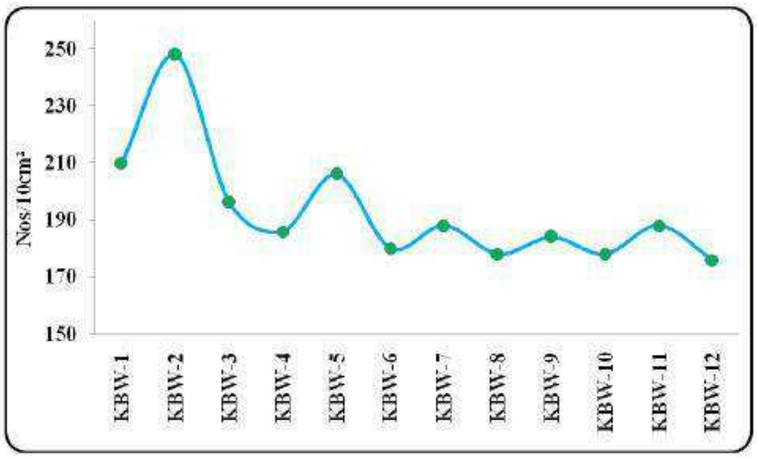


Fig. 51. Population density of Meio-fauna recorded in various stations of Kaluveli backwaters

Percentage composition:

The results of percentage composition of Meio-fauna revealed that Foraminifera constituted the maximum with 57% of the total Meio-benthic organisms. Nematodes, Harpacticoid and Ostracods contributed to 24%, 10% and 9% respectively to the total Meio-benthic samples collected (Fig. 52).

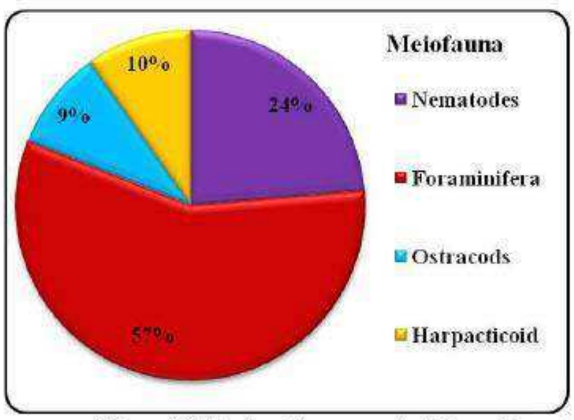


Fig. 52. Percentage composition of Meio-benthos recorded in various stations of Kaluveli backwaters

Diversity Indices

The Meio-benthos species diversity (H') varied from 2.735 to 3.621 with maximum was in KBW-2 and minimum in KWB-11 and similarly the species richness (d) ranged between 4.867 and 6.635 with maximum in KBW-6 and minimum in KWB-9. The species evenness varied from 0.741 to 0.912 with the maximum in KWB-2 and minimum in KWB-10 (Table 9).

Table 9. Diversity indices a-Shannon diversity (H'); b-Margalef richness (d) and c- Pielou's evenness (J') calculated for Meio benthos in Kaluveli backwaters

Stations	Shannon diversity (H')	Margalef richness (d)	Pielou's evenness (J')
KBW-1	2.794	5.839	0.907
KBW-2	3.621	5.461	0.912
KBW-3	3.050	5.317	0.847
KBW-4	3.102	5.406	0.829
KBW-5	3.113	5.249	0.896
KBW-6	3.175	6.635	0.820
KBW-7	2.917	5.724	0.784
KBW-8	2.886	6.532	0.771
KBW-9	3.076	4.867	0.814
KBW-10	2.928	5.392	0.753
KBW-11	2.735	5.467	0.780
KBW-12	2.786	5.784	0.796

Cluster analysis

To find out the similarity/dissimilarity between stations, as done for plankton data, the benthic faunal abundance data (macrofauna and meiofauna) were amalgamated and subjected to classification and ordination methods. The resulting dendrogram revealed that the stations near coastal zone KBW-1, KBW-4, KBW-3 and KBW-2 formed a separate cluster and stations within the backwaters zone namely KBW-5, KBW-12, KBW-6, KBW-11, KBW-10, KBW-7, KBW-8 and KBW-9 formed separate clusters based on the species composition and abundance (Fig. 53). This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.17), which is overlying on the top-right corner of the MDS plot, was also found to be low signifying the good ordination pattern of the samples (Fig. 54).

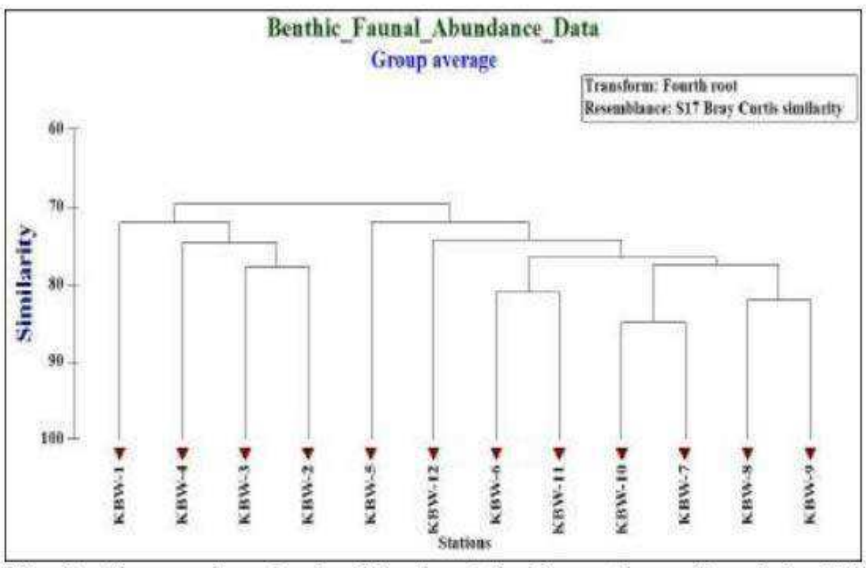


Fig. 53. Dendrogram for the benthic fauna/abundance data collected in Kaluveli backwaters

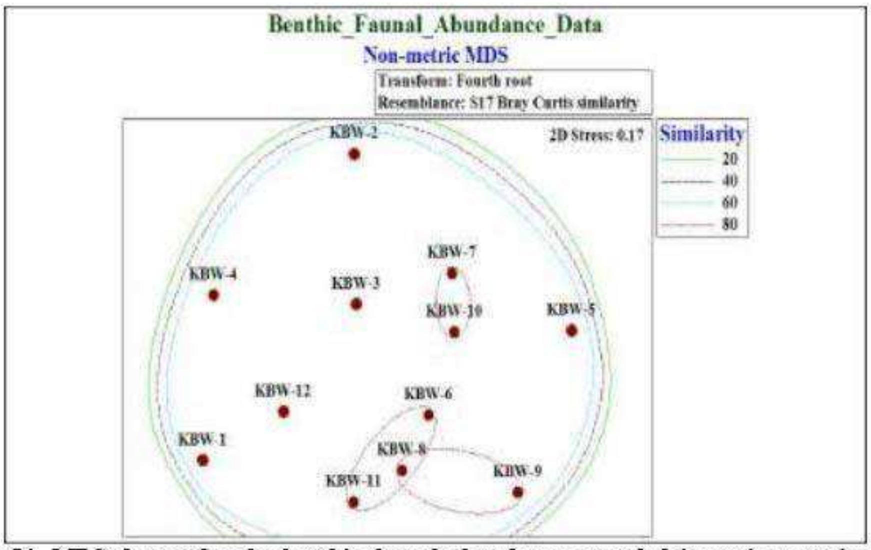


Fig. 54. MDS drawn for the benthic faunal abundance recorded in various stations of Kaluveli backwaters

5.16. BIO-ENV (Biota-Environment matching)

As done for plankton data, the BIO-ENV matching was employed to measure the rank correlations of the benthic faunal abundance (Bray-Curtis similarity) and environmental (Euclidean distance) matrices as well. For this, eight environmental variables (Temperature, Salinity, Dissolved Oxygen, Silt, Sand, Clay, TOC and Soil pH) were allowed to match the biota. The results revealed that, a combination of seven environmental parameters ($p\omega = 0.973$) namely TOC, Temperature, Salinity, Clay, Slit, Soil pH and Sand got manifested as best match in determining benthic faunal distribution followed by Temperature, Sand, Salinity, Dissolved Oxygen and TOC ($p\omega = 0.926$) which also got manifested as second best variable combinations, in determining the faunal distribution in the Kaluveli backwaters (Table-10).

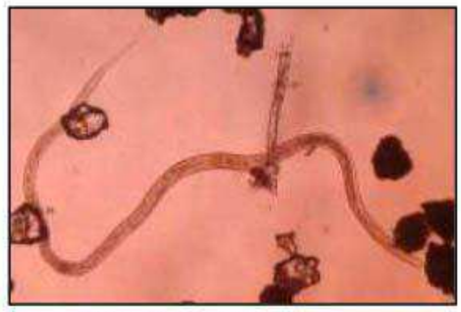
Table -10. Harmonic rank correlations (ρω) between benthic faunal (both Macro-benthos and Meio-benthos) abundance against environmental variables in Kaluveli backwaters

S. No.	No. of variables	Best variable combinations	Correlation (ρω)
1.	7	TOC - Temperature - Salinity – Clay - Silt - Soil pH – Sand	0.973
2.	6	Temperature - Sand - Salinity – Dissolved Oxygen – TOC	0.926
3.	6	Dissolved Oxygen - TOC – Salinity - Clay – Soil pH – Sand	0.871
4.	5	Salinity - Clay - TOC – Soil pH - Silt	0.835
5.	5	Sand – Clay – Soil pH - Dissolved Oxygen – Salinity	0.782

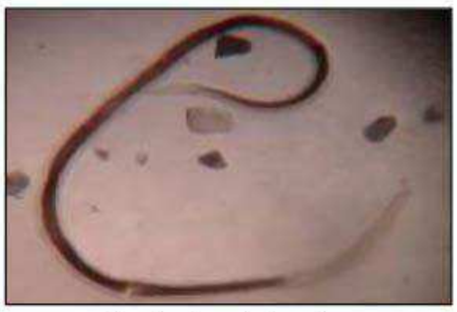
PLATE-IV COMMON MEIO-BENTHOS

NEMATODES

Halalaimus filum



Astomonema jenneri



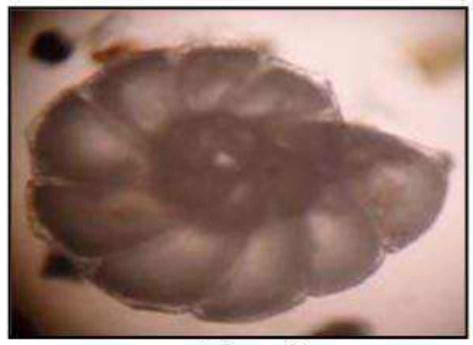
Oxystomina clavicauda

Neochromadora craspedota

Daptonema conicum

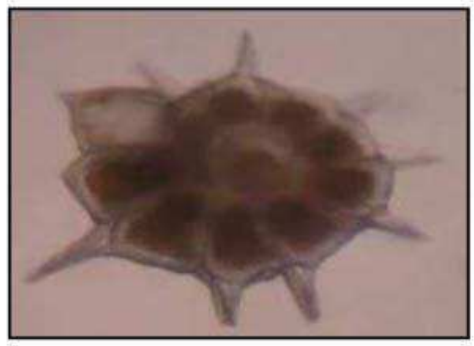
FORAMINIFERANS

Ammonia tepida



A. beccarii

Elphidium advenum

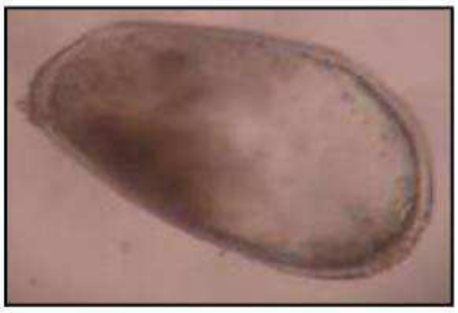


Asterorotalia pulchella

Spiroloculina angulosa

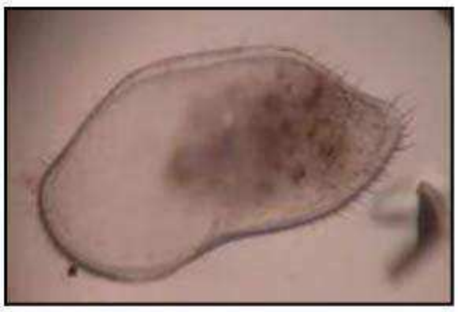
Spirillina limbata

OSTRACODES



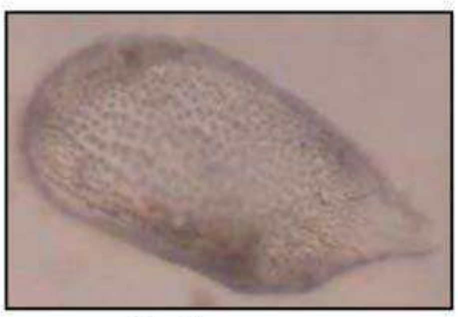
Keijella reticulata

Basslerites liebaui

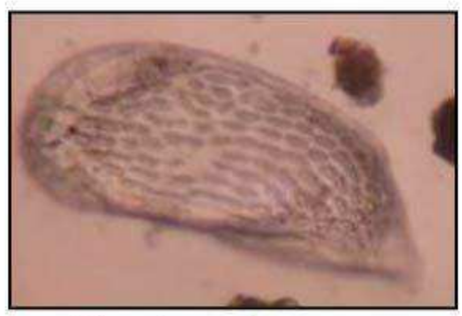


Bairdoppilata scaura

***Paracytherideis* sp**



Eucythere argus



Microcytherura nigrescens

HARPACTICOIDS

Macrosetella gracilis

Canuella perplexa

Leptastacus mocronyx

Harpacticus chelifer

OTHER ECOLOGICALLY SENSITIVE GROUPS

Corals

Corals were not found in the proposed site and its periphery.

Other Endangered Species

No reserve forest, protected forest, Sea horse, Indian otter, Salt water crocodile, marine mammals, elephant and tiger reserve was recorded within 10 km radius of the project site.

Coastal vegetation

The survey conducted in the project region revealed the sporadic occurrence of plant species such as Coconut tree, Eucalyptus tree, *Solanum aculeatissimum, Spinifix littoralis, Phyllanthus rotundifolia, Borassus flabellifer, Solanum xanthocarpum.* Giant *calotrope, Phoenix pusilla, Ipomea biloba* and *Ipomoea pes*-caprae. However, Ramanujam (2005) recorded the following common aquatic vegetation in the study area. They are *Aponogeton natans, Eichhornia crassipes, Hydrilla verticillata, Limnophyton obtusifolium, Monochoria vaginalis, Vallisneria spiralis, Aristida adscensionis, Chloris barbata, Chloris Montana, Polygala arvensis, Lindernia crustacean, Scoparia dulcis, Waltheria indica, Acacia nilotica, Alternanthera sessilis, Bacopa monnieri, Coldenia procumbens, Cyperus distans, Eclipta prostrate, Heliotropium indicum, Hygrophila angustifolia, Ludwigia perennis, Phyla nodiflora, Polygonum barbatum, Typhya angustata, Prosopis juli-flora, Barringtonia* and *Acacia nilotica.*

Seaweed and Seagrass

The Seagrass species like *Halodule uninervis*, *Halophila ovalis*, *Halophila* sp., and filamentous macro-algae like *Chaetomorpha* spp, *Enteromorpha* sp, *Ulva* sp, *Cladophora* sp, *Acetabularia* sp etc. were recorded from the surveyed stations. Their distribution is confined to shallow coastal areas where the depth is less than a meter.

Avifauna

During the survey a wide variety of migratory water fowls, notably Pelicans, Herons and Egrets, Storks, Flamingoes, Ducks, shore-birds, Gulls and Terns were recorded from the surveyed stations. Nevertheless, Balachandran (1994) reported as many as 179 species of birds from Kaluveli coastal waters. Of the 179 species, 30 are shore birds and waders, while 13 species are ducks. Generally, large congregation (in thousands), of wetland birds can be seen from October to March, since the ecological conditions of the wetland during this period are highly suitable for the migratory birds and these the wetland serves as an important corridor for the migratory birds, which visit the Point Calimere Bird Sanctuary.

Shore birds

<u>The impact of the project on migratory birds</u>

The proposed project site is known for operation of fishing boats fitted with Low HP engine, which may not create noise with high decibel to scare the migratory birds who visit the project site often.

Not only is that, the proposed project will not cause any significant disturbance or dislocation of the nearby intertidal/mudflat area. Further, due to mangrove afforestation program, the roosting site of the proposed area will also get increased and thus it will indirectly attract more number of migratory and local avifauna.

Fisheries

The following marine fishes namely Mackeral, Seer fishes, Grouper, Pomfrets, Tuna, Squids, pony fish, sharks, flying fish, cat fish, prawn, silver bellies, crabs, rays and other miscellaneous varieties were caught commonly from this region. The fishermen in the fishing villages venture out for fishing using trawlers, FRP (Fiber Reinforced Plastic) boats besides country boats through deploying gears such as Gill net, Trawl net, Flying fish net, Crab net and Ray fish net. However, Ramanujam (2005) reported 42 species of fishes representing 25 families and 09 orders from the Kaluveli backwaters. Out of these, 6 were confined to the flood plain, 19 were estuarine and 17 in both floodplain and creek. Both anadromous and catadromous migratory fish species were observed in this region.

Marine protected area

Ministry of Environment and Forests, Government of India, has identified 94 important wetlands in India, of which three are in Tamil Nadu state viz., Point Calimere, Pallikaranai and Kaluveli (Kazhuveli) wetlands. The Kaliveli watershed is the second major brackish water lake in South India. It is a semi-permanent, fresh to brackish wetland that drains 776 km^2 along the Coromandel Coast. Kaliveli is considered as a Wetland of International importance proposed by International Union for the Conservation of Nature and Natural Resources (IUCN). The Kaliveli wetland ecosystems have often been seen as unproductive and stinking, and thus removed to make land areas for human settlements, infrastructure development, aquaculture, agriculture saltpan and other industrial activities and tourism development. There is no national park, wildlife sanctuary and biosphere reserve within 10 km radius of the study area.

Therefore, the training walls proposed for stability of bar mouth in this region, will not have any significant impact on flora and fauna.

Status of Mangroves

The Ecological security of the coastal zone of India is in stress due to high population density, environmental degradation and frequent disasters like tsunami and cyclones. Mangroves are defined as woody trees and shrubs that grow in places where river water mixes with seawater. These are unique plants which are extremely important as coastal resources and it is important to socio-economic development of majority of population living in the coastal areas. Mangrove forests have been shown to sustain number of direct and indirect human activities, ranging from fuel-wood for the local community to mangrove based fisheries. Even though, mangroves are important productive ecosystems with high economic potential and they are vulnerable manmade degradation or cleared for the purpose of industrial developments. The mangrove forests establishing a thick coastline near estuarine/ backwater areas and it act as shield against natural disasters like cyclone, storms and Tsunami. Mangroves support multiple forest products for the local dependent population. Mangroves provide high value commercial products and fishery resources and a suitable location for ecotourism. In the present survey, patchy occurrence of stunted mangrove species *Avicennia marina* and mangrove associates *Suaeda* sp. was noticed near the proposed site.

Avicennia marina

Mangrove Monitoring Plan

Weekly Monitoring- Damage of propagules and fence would be monitored and maintained. Disease and pest attack on afforested mangrove sapling would be monitored regularly

Monthly Monitoring- Health in terms of growth of mangrove species would be monitored for achieving the successful plantation of mangroves in the proposed sites

Quarterly Monitoring- Once the plantation is done, Gap filling will be carried out wherever the mangrove saplings is not grown with the fresh mangrove propagules so as to keep the mangrove patches as dense. Similarly, fencing in and around mangrove planted area will be maintained so as to prevent cattle grazing and other anthropogenic disturbances

Nursery Monitoring- Equally, importance will be given to nursery since the incidence of diseases and pest infestation is quite common in mangrove nursery and therefore it is necessary to monitor daily and suitable remedial measures will be taken. If required, the necessary intervention in terms of insecticide/pesticides/ weedi-cide would be made to maintain the health of mangrove saplings in the nursery.

Status of turtle nesting

According to personal Interview with local inhabitants, nesting occurs (roughly 40-70 nestings) at both north and southern side of river mouth every year in the region (5 km radius). The Forest department of the State Government maintains the data regarding turtle nesting along the coast. Every year, the sporadic nesting of *Lepidochelys olivacea* turtle is found in this region. A female lays about 120 to 140 eggs in a pit. The incubation period for the eggs to hatching is about 40 to 60 days with a hatching rate of over 95%. Incidentally, the domestic and wild animals pose a threat to the eggs and the hatchlings in the nesting sites. Further, dead carcasses were observed during our survey and further investigation on this with locals revealed that about 70 to 80 cases of incidental mortality of mature Turtles happen every year in this region as they get entangled in the gill and trawl nets operated in this region. As a whole, the nesting activities in the area surrounding the proposed site are very sporadic and meager in number compared to the Gahirmatha coast of Orissa, wherein the intensity is high.

Lepidochelys olivacea

The impact of training wall on sea turtle nesting

As the training wall is proposed to establish perpendicular to the river for preventing the sand bar formation or to keep the river mouth open, the said structure will not occupy the beach zone of the coast. Therefore, it will not have any significant impact on the turtle nesting in the proposed project site.

COMMONLY RECORDED FLORA

Solanum aculeatissimum

Prosopis juliflora

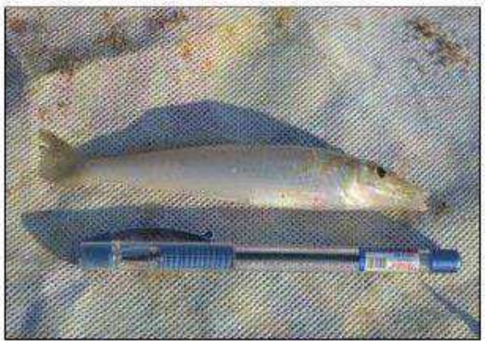
Borassus flabellifer

Giant calotrope

Phoenix pusilla

Ipomoea pes-caprae

COMMERCIALLY IMPORTANT FISHES



Sillago sihama

Mugil cephalus

Scatophagus argus

Upeneus sp.

Gerres filamentosus

Leiognathus sp.

5. SUMMARY AND CONCLUSION

In the present survey, which lasted for two days, the physico-chemical and biological parameters were analyzed both in the water and sediment samples from predetermined (12 stations) locations of Kaluveli backwaters. The physico-chemical parameters studied did not vary much barring a few parameters which showed only marginal variations. The results of various parameters are summarized below:

The surface water temperature varied from 24.1 to 26.5°C. The salinity varied from 5.0 to 28.0PSU. Hydrogen ion concentrations in surface waters remained alkaline and the maximum value of 7.9 was recorded at KBW-2. The observations made on the prime physical factors such as TSS and turbidity was within the permissible level. The turbidity ranged between 7.3 and 8.4NTU. The TSS values fluctuated from 89.5 and 120.6ppm. The maximum TSS and turbidity values were found recorded at KBW-6 and minimum at KBW-10. The variation noticed between the stations is only marginal, which might be due to seasonal, geographical location and tidal influence.

The range of ecologically sensitive chemical parameters such as Dissolved Oxygen, BOD, nutrients were also at the optimal concentration conforming to the seasonal trend. The oxygen level fluctuated from 4.482 and 5.831mg/l, with the maximum DO level was recorded at KBW-10 and the minimum was recorded at KBW-4. The DO concentration remained fairly well within the prescribed limit of water quality. The BOD level was found to be ranged from 0.546 and 1.024mg/l with the maximum BOD was observed at KBW-4 during this survey.

In the present investigation, the ammonical nitrogen concentration ranged between 0.15 to 0.24µmol/l. The concentration of nitrite fluctuated from 1.28 to 2.36µmol/l. The nitrate values ranged from 1.87 and 3.27µmol/l and the total nitrogen varied between 13.92 to

22.18µmol/l. The inorganic phosphate ranged from 0.48 and 1.09µmol/l. The observed total phosphorus values ranged between 1.75 to 3.04µmol/l. The silicate concentration ranged from 40.82 and 52.69µmol/l. The particulate organic carbon values ranged from 75.34 and 118.09µgC/l respectively.

In the present survey, Petroleum Hydrocarbon in water varied between 0.183 and 0.305µg/l. with higher concentration at station KBW-1. The total organic carbon content varied from 4.8 and 6.6mgC/g with the maximum was at KBW-6 and minimum at KBW-1. The present survey showed that the Petroleum hydrocarbon relatively higher in sediment than the water and the values ranged from 0.233 to 0.405µg/g. The maximum was recorded at KBW-1 and the minimum was recorded at KBW-9 during this survey.

The level of metal concentrations recorded in the present study is comparatively lesser than the earlier reports from the study area except for Iron. The sediment Iron concentration was found to be higher (1068.5 to 1762.4µg/g) compared to the level in water (8.23 to 9.35µg/L). The maximum was recorded at KBW-10 and the minimum was recorded at KBW-1. In general, areas experiencing high shipping and boating operations are usually to record higher Iron concentration. The concentration in coastal sediment samples indicates that it is well within the ERM (Effective Range Median) which mean there are no possibilities of Heavy metal contamination in the region.

The sand, silt and clay fraction at each station along with their textural classification indicated that the Clay and Sand percentage was higher during this survey.

Principal Component Analysis (PCA) is considered to be effective as they can reveal information from data sets containing larger amounts of variance, simultaneously considering the inter-relationships of several influential variables. Further, this method also allows us to analyze patterns in biotic data and to relate biotic patterns to spatial-temporal environmental variables (Field *et al.*, 1987). It is understood that environmental factors can modify, support or augment each other by acting independently or in combination as has been stated by Kinne (1964).

The PCA plot drawn for the physico-chemical parameters collected in water samples were subjected to Principle component analysis to set a well-defined relation between the environmental parameters against the surveyed stations. The PCA plot drawn indicated that water parameters such as Temperature, Depth, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO_2, NO_3, NH_3, TN, TP, IP, SIO_4, POC, W.PHC, Cu, TOC, sand and Cr had significant correlation with the surveyed stations. Looking at the nature of correlation, the parameters such as Temperature, DO, Salinity, pH, TSS, Turbidity, Primary Productivity, NO2, NO3, TN, TP, SIO4, POC, IP, PHC, Cu, TOC and TSS got correlated with stations KBW-2, KBW-3, KBW-4, KBW-5 and KBW-1 while the rest of the parameters showed strong correlation with stations KBW-9, KBW-10, KBW-11, KBW-12, KBW-8 and KBW-7. Similar combinations of parameters with stations were also obtained earlier from Chennai coast by Kuppusamy and Giridhar (2006) and Mohanty *et al.* (2014).

The microbial population showed typical seasonal trend in water and sediment samples during this survey. The maximum colony count was observed in sediment when compared to the water samples.

The chlorophyll '*a*' in water sample varied from 0.942 to 2.935 mg/m^3, with maximum at KBW-3 and minimum at KBW-11. The Phaeopigments content varied from 0.925 to 3.075 mg/m^3 with maximum was at KBW-3 and the minimum was observed at KBW-11. The Total biomass values varied from 1.102 to 3.419 ml/100m^3, with maximum at KBW-3 and minimum at KBW-11. The primary productivity was measured using the dark and light reaction method.

The values ranged from 120.31 to 201.38mgCm^{-3}d^{-1}. The maximum value was recorded at KBW-3 and minimum value at KBW-10.

In the present study, as many as 54 phytoplankton species belonging to thirteen groups namely Bacillariaceae, Naviculoideae, Bellerocheaceae, Biddulphoidae, Chaetocereae, Coscinodisceae, Eucampiinae, Asterionellaceae, Soleniceae, Triceratiinae, Ceratiaceae, Peridiniaceae, Prorocentraceae, Dinophysiaceae and Blue Green algae were recorded. Of these, Coscinodisceae were found to be the dominant group with 8 species. Chaetocereae and Naviculoideae formed next dominant groups with 6 species and Soleniceae with 5 species, Triceratiinae and Blue Green algae with 4 species each. Dinophysiaceae, Ceratiaceae and Bacillariaceae with 3 species each and Bellerocheaceae, Biddulphoidae, Eucampiinae, Asterionellaceae, Peridiniaceae and Prorocentraceae came last in the order with 2 species each. Density of phytoplankton varied from 8384 to 14674 Cells/l with maximum was at KBW-1 and minimum at KBW-11. The phytoplankton species diversity (H') varied from 2.894 to 3.867 with maximum value was recorded at KBW-2 and minimum at KBW-10. The species richness (d) ranged between 4.768 and 6.421 with maximum at KBW-12 and minimum value was recorded at KBW-1. The species evenness varied from 0.832 to 0.926 with the maximum value was recorded at KBW-3 and minimum at KBW-11.

Coming to zooplankton, density varied from 6,556 to 7,068 Nos/m^3 with maximum at KBW-3 and minimum at KBW-11. During the survey, a total of 50 species belonging to 6 groups of macro zooplankton namely, Calanoid copepods, Cyclopoid copepods, Harpacticoid copepods, Ciliates, Rotatoria and Other Crustacean forms, and 5 groups of micro zooplankton namely, Mollusca, Larvacean, Pteropoda, Foraminifera and Annelida were recorded. In macro zooplankton, Calanoid copepod was found to be the dominant group with 14 species. Ciliates came as next dominant group with 8 species and Cyclopoid copepod with 7 species. Harpacticoid and other Crustacean forms came next in the order with 5 species each. Among microzooplankton, Larvacean and Foraminifera were recorded with 3 species each and Mollusca, Rotatoria with 2 species each and Annelida and Pteropoda with 1 species each to the total zooplankton abundance. As done for phytoplankton, the zooplankton species diversity (H') varied from 2.528 to 3.736 with maximum in KBW-2 and minimum in KBW-9. The species richness (d) ranged between 4.639 and 6.683 with maximum in KBW-6 and minimum in KBW-3. The species evenness varied from 0.764 to 0.927 with the maximum in KBW-2 and minimum in KBW-10.

Regarding classification and ordination techniques, the results revealed that stations near to the coastal zone KBW-1, KBW-3 and KBW-2 formed a separate cluster based on species composition and abundance. The remaining stations within the backwaters namely KBW-7, KBW-8, KBW-4, KBW-9 and KBW-11, KBW-6, KBW-12, KBW-5 and KBW-10 formed separate clusters. This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.07), which is overlying on the top-right corner of the MDS plot, was also found to be low signifying the good ordination pattern of the samples. The grouping of stations might be based on the variation in species composition in near shore and back waters besides fluctuations in environmental variables between the stations as evidenced by Sahu *et al.* (2010); Robin *et al.* (2013) from Chennai coastal waters; Janakiraman et al. (2013); Baliarsingh et al. (2014) and Srichandan et al. (2015) from east coast of India.

The BIO-ENV results indicated that the parameters such as Dissolved Oxygen, Salinity, Primary productivity, Total biomass, Chlorophyll 'a', Total Nitrogen, Silicate and Total phosphate were featured as the major variables explaining the best match (ρω= 0.964) with plankton (both phytoplankton and zooplankton) distributions. The other parameters such as Dissolved Oxygen, Temperature, Inorganic phosphate, Primary productivity, Silicate, Chlorophyll 'a' and Total Nitrogen also got manifested in the next best variable combinations in determining the plankton distribution in Kaluveli backwaters. This view point agrees well with the earlier researchers as they have pointed out that these parameters are the most important factor in determining the distribution of phytoplankton and zooplankton abundance in estuarine environments (Juggins, 1992; Hassan *et al*., 2007).

As regards macro benthic organisms, the population density varied from 100 to 1900 Nos.m^{-2} with maximum at KBW-2 and minimum at KBW-12. Altogether, 37 species of macro fauna were recorded from surveyed stations. Altogether, 37 species of macro fauna were recorded from surveyed stations. Of these, polychaetes topped the list with 21 species. Bivalves were found to be the next dominant group in the order of abundance with 9 species. Gastropods and group others came next in the order with 4 and 2 species respectively of the total benthic organisms collected. One species of amphipod was recorded during the present study. The macrobenthos species diversity (H') varied from 2.47 to 3.83 with maximum in KBW-2 and minimum in KBW-12. The species richness (d) ranged between 4.46 to 6.82 with maximum in KBW-12 and minimum in KBW-2. The species evenness varied from 0.81 to 0.97 with the maximum in KBW-2 and minimum in KBW-12.

Regarding meiobenthic organisms, the population density of Meio-benthic fauna varied from 176 to 248Nos/10cm^{-2} with maximum was at KBW-2 and minimum at KWB-12. In the present study, as many as 44 species belonging to four groups of Meio-benthic organisms namely Foraminiferans, Nematodes, Ostracods and Harpacticoids were recorded. Among them, Foraminiferans topped the list with 26 species. Nematodes and Ostracods were found to be the next dominant groups in the order of abundance with 7 species each and Harpacticoids came next with 4 species. The Meio-benthos species diversity (H') varied from 2.735 to 3.621 with maximum was in KBW-2 and minimum in KWB-11 and similarly the species richness (d) ranged between 4.867 and 6.635 with maximum in KBW-6 and minimum in KWB-9. The species evenness varied from 0.741 to 0.912 with the maximum in KWB-4 and minimum in KWB-8.

The dendrogram revealed that, as in plankton study, the stations near coastal zone KBW-1, KBW-4, KBW-3 and KBW-2 formed a cluster and stations within the backwaters zone KBW-5, KBW-12, KBW-6, KBW-11, KBW-10, KBW-7, KBW-8 and KBW-9 formed separate cluster based on the species composition and abundance. This fact was further confirmed through MDS, which was also revealing the same pattern of groupings as observed in cluster analysis. The stress value (0.17), which is overlying on the top-right corner of the MDS plot, was also found to be low signifying the good ordination pattern of the samples. Similar groupings in intertidal and inshore waters based on benthic fauna was reported earlier by Ajmal Khan *et al*. (2005); Tolhurst and Chapman (2007) and Martins *et al*. (2016).

The BIO-ENV matching indicated that the combination of seven environmental parameters (pω = 0.973) namely Dissolved Oxygen, Temperature, Salinity, Clay, Slit, Soil pH and Sand got manifested as best match in determining benthic faunal distribution followed by Temperature, Sand, Salinity, Dissolved Oxygen and TOC (pω = 0.926) which also got manifested as second best variable combinations, in determining the faunal distribution in the Kaluveli backwaters. True to this fact, in a study made by Murugesan (2002), Muthuvelu (2013) and Sivaraj (2014) reported the similar combinations of environmental variables influencing the macro-benthic and meio-benthic faunal distribution.

Regarding ecologically sensitive groups like Corals, marine mammals, elephant and tiger reserve was not recorded within 10 km radius of the project site. The survey conducted in the project region revealed the sporadic occurrence of some plants such as Coconut tree, Eucalyptus tree, *Solanum aculeatissimum, Spinifix littoralis, Phyllanthus rotundifolia, Borassus flabellifer, Solanum xanthocarpum,* Giant *calotrope, Phoenix pusilla, Ipomea biloba* and *Ipomoea pes-caprae*.

Further, the secondary data revealed the presence of plant species such as *Aponogeton natans, Eichhornia crassipes, Hydrilla verticillata, Limnophyton obtusifolium, Monochoria vaginalis, Vallisneria spiralis, Aristida adscensionis, Chloris barbata, Chloris Montana, Polygala arvensis, Lindernia crustacean, Scoparia dulcis, Waltheria indica, Acacia nilotica, Alternanthera sessilis, Bacopa monnieri, Coldenia procumbens, Cyperus distans, Eclipta prostrate, Heliotropium indicum, Hygrophila angustifolia, Ludwigia perennis, Phyla nodiflora, Polygonum barbatum, Typhya angustata, Prosopis juli-flora, Barringtonia* and *Acacia nilotica* in the nearby region.

The Seagrass species like *Halodule uninervis*, *Halophila ovalis*, Halophila sp., and filamentous algae like *Chaetomorpha* spp, *Enteromorpha* spp, *Ulva* spp, *Cladophora* spp, *Acetabularia* spp. etc. were recorded from the surveyed stations. Their distribution is confined to shallow coastal areas where the depth is less than a meter.

During the survey a wide variety of migratory water fowls, notably pelicans, herons and egrets, storks, flamingoes, ducks, shore-birds, gulls and terns were recorded from the surveyed stations.

With respect to fisheries potential, the most dominant fish species recorded during the survey were Mackeral, Seer fishes, Grouper, Pomfrets, Tuna, Squids, Leognathus, sharks, flying fish, cat fish, prawn, silver bellies, crabs, and rays. The fishermen in the fishing villages venture out for fishing using trawlers, FRP (Fiber Reinforced Plastic) boats and country boats through deploying gears such as Gill net, Trawl net, Flying fish net, Crab net and Ray fish net for fishing. Even though Kaliveli is considered a wetland of international importance by International Union for the Conservation of Nature and Natural Resources (IUCN), this wetland ecosystems have now been seen as unproductive and stinking, and thus removed to make land areas for human settlements, infrastructure development, aquaculture, agriculture saltpan and other industrial activities and tourism development. There was no national park, wildlife sanctuary and biosphere reserve within 10 km radius of the study area.

In the present survey, patchy occurrence of stunted mangrove species *Avicennia marina* and mangrove associates *Suaeda* sp. was noticed near the proposed site. Further, sizeable area has also been identified and proposed in EMP for mangrove plantation. With respect to turtle movement, according to personal Interview with local inhabitants, nesting occurs (roughly 40-70 nestings) at both north and southern side of river mouth every year in the region (5 km radius). The Forest department of the State Government maintains the data regarding turtle nesting along the coast. Every year, the sporadic nesting of *Lepidochelys olivacea* turtle is found in this region. A female lays about 120 to 140 eggs in a pit. The incubation period for the eggs to hatch out is about 40 to 60 days with a hatching rate of over 95%. The domestic and wild animals pose a threat to the eggs and the hatchlings in the nesting sites. Further, dead carcasses were observed during our survey and further investigation on this with locals revealed that about 70 to 80 cases of incidental mortality of mature Turtles happen every year in this region as they get entangled in the gill and trawl nets operated in this region. As a whole, the nesting activities in the area surrounding the proposed site are very sporadic and meager in number compared to the Gahirmatha coast of Orissa, where the intensity of nesting is high.

On the whole, the results of physico-chemical and biological parameters indicated that the water is well oxygenated and nutrients are adequate supporting fairly good plankton population, the base in the food chain. Not only is that, the metal concentration in coastal water and sediment samples indicates that it is well within the ERM (Effective Range Median) values (Long *et al*., 1995) which means there is no possibilities of Heavy metal contamination in the region. More importantly, diversity indices calculated for the plankton and benthic data in the present study clearly indicated the undisturbed nature of the environment since diversity values of plankton and benthos were found to be more than 2.5 in the study area as stated by Ecologist Sanders (1968). Not only that, the macro benthic conservative species was predominantly occurred in the Kaluveli backwaters, which is again reflecting the undisturbed nature of the ecosystem.

In short, the marine ecological survey made during 12th to 13th December 2020 in Kaluveli backwaters and careful perusal of the available information suggested that the water quality parameters are within the safe level and did not indicate any alarming impact on the existing biological components. The analysis on other ecologically sensitive organisms reflected the patchy occurrence of a few groups especially Mangroves, Birds, Seagrass and Seaweeds from the nearby regions. The proposed facility will result in only marginal impacts on biota but such impacts are confined to a limited period since most of the marine organisms are capable of recouping themselves quickly to its original form and thus there will not be any pronounced change to the biota. Nevertheless, a suite of Environmental Management Plan (EMP) and mitigation measures is suggested below.

Further, as the present marine survey was done only a short period, a long term intensive survey of this kind, at least Five to Seven year in a row, is warranted during and after commissioning of this proposed facility in order to pin point the temporal variations in the physico – chemical and biological components of this environment arising out of the proposed facility.

Environmental management plan (EMP) for Marine Biodiversity study, Mangrove afforestation and Turtle conservation measures for construction of Fishing Harbour in Kaluveli backwaters

Tamil Nadu Government is keen to expand the fishing harbours and fish landing Centers to ensure hygienic handling of fishes and thereby fetching higher cost for the fishes. Creation of fishing harbours and fish landing centers provide a new dimension to the livelihood of the fishing community. Thus, fishing harbours are mooted with ancillary facilities, like auction hall, net mending shed, ice plant etc. Following this plan, Government of Tamil Nadu has already constructed many fishing harbours and fish landing Centers in east and west coasts of Tamil Nadu. Regrettably, there is no fishing harbor facility in Villupuram and Kancheepuram districts. Hence, the Government of Tamil Nadu proposed to construct the fishing harbours for safe berthing of fishing boats operated in the major fishing Villages of Villupuram and Kancheepuram Districts. Accordingly, suitable site has been identified for construction of Fishing Harbour in Kaluveli waters at Azhagankuppam in Villupuram district and Alamparaikuppam in Kancheepuram district

As part of statutory compliance requirement, a comprehensive Marine Environmental monitoring was planned and accordingly the Centre of Advanced Study (CAS) in Marine Biology of Annamalai University, Tamil Nadu was engaged to carry out the Marine Ecological feasibility survey. An extensive survey was made during 12th – 13th December 2020 at Kaluveli coastal waters and during this survey, sea water, sediment and biological samples (Plankton, Benthos, microbiological and other ecologically important flora and fauna especially mangrove and Turtle movement) was collected from 12 different stations from the proposed site.

Through this EIA study, expected impacts on marine ecology arising out of the proposed project was recognized and a detailed **Environment Management Plan (EMP)** to mitigate and manage the impacts caused to the marine biota during construction and operation phase of the proposed project was prepared accordingly.

Impact, Mitigation, Conservation and Management Plan

Various fishing harbor related activities including fishing, dredging operations, materials disposal, shore zone development and vehicular traffic in the harbors can results in the release of natural and anthropogenic contaminants to the environment.The potential impacts on the marine environment due to the development of new fishing harbor in the proposed site have been identified considering the nature and extent of the activities associated with the project implementation and operation and they are given below and to mitigate likely environmental impacts during construction and operation phases from the land and marine activities, suitable mitigation measures to tide over the expected risks are also given below:

1. Coastal habitats may be destroyed and navigational channels silted due to causeway construction and land reclamation.
2. Deterioration of surface water quality may occur during both the construction and operation phases.
3. Fishing operations may produce sewage, bilge wastes, solid waste and leakage of harmful materials both from shore and boats.
4. Oil pollution is one of the major environmental hazards resulting from harbour and shipping operations.

WATER QUALITY MAINTENANCE AND PROTECTION TO MARINE ORGANISMS

- ✓ Turbidity levels will be maintained as to the baseline data by continuous monitoring and proper care by way of stopping the activities whenever there is increase in turbidity by way of land sliding/bottom turbulence so avoid any impact either to water quality or to marine organisms
- ✓ Discharge of waste into the sea will be prohibited
- ✓ Ensure that slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste
- ✓ Marine environmental monitoring as per environmental monitoring programme
- ✓ Dredge Management Programme shall include measures to avoid entrapment of macro marine fauna.
- ✓ Care should be taken to prevent the contaminated runoff from the construction site to the nearby natural streams, if any
- ✓ Optimized utilization of the water
- ✓ Wastewater and sewage generated shall be treated in septic tanks with soak pits without draining into the marine environment
- ✓ Discharge of treated wastewater as per marine discharge standards
- ✓ Fishing vessels will be prohibited from discharging wastewater, bilge, oil wastes, etc. into the near-shore as well as harbour waters by adopting International Convention for the Prevention of Pollution from boats and Ships (MARPOL) 1974/1978, Consolidated Edition, IMO, 1991, including 1992 amendments to Annex 1 and 2002 amendments
- ✓ Regular Interactions shall be initiated with the fishing community and conflicts, if any with fishing community shall be amicably resolved in all cases.
- ✓ Shoreline Protection Techniques such as Sand by passing if any will be carried out

1. Marine Environmental Monitoring

It is suggested that a continuous Marine Ecological Impact Assessment covering all the seasons at least 5 to 7 years in a row, on various aspects of the coastal environs need to be undertaken by a competent organization like Centre of Advanced Study in Marine Biology, Annamalai University, who has vast and rich experiences in marine science aspects. The monitoring should cover various physico-chemical parameters coupled with biological indices such as microbes, plankton, benthos and fishes on a periodic basis for not less than five year period. The monitoring should commence during construction and operation of the project. Any deviations in the parameters should be given adequate care with suitable measures to conserve the marine environment and its resources. Further the data collected should also be compared with secondary data available for the Kaluveli backwaters so as to arrive a meaningful management plan.

In order to conserve the coastal waters adjacent to the project site area and also to enhance the livelihood options of the fishermen communities located in and around this area, who are solely depending on this ecosystem to eke out their living, a holistic environmental management plan with adequate conservation measures, judicious utilisation of marine bio-resources besides novel technologies for adoption by fishermen so as to enhance the additional and alternate livelihood option are also given below.

2. Mangrove Afforestation

The Ecological security of the coastal zone of India is in stress due to high population density, environmental degradation and frequent disasters like tsunami and cyclones. To mitigate the impact of coastal disasters, the proposed intervention would be a model and it can be replicated to other regions of the country. Mangroves are defined as woody trees and shrubs that grow in places where river water mixes with seawater. These are unique plants which are extremely important as coastal resources and it is important to socio-economic development of majority of population living in the coastal areas. Mangrove forests have been shown to sustain number of direct and indirect human activities, ranging from fuel-wood for the local community to mangrove based fisheries. Establishment of mangrove forests in a thick coastline near estuarine/ backwater areas will act as shield against natural disasters like cyclone, storms and Tsunami. Mangroves support multiple forest products for the local dependent population. Mangroves provide high value commercial products and fishery resources and a suitable location for ecotourism. It also regulates functions by reducing coastal erosion and also minimizing flooding. The Centre of Advanced Study in Marine Biology, Annamalai University has been in a mission of mangrove afforestation programme along the East coast (Cuddalore and Pondicherry) involving stakeholders like fishermen, tribals towards enhancing the ecological security of the coastal areas and the livelihood security of the coastal dependent people for last two decades. Considering their expertise and experience, it is proposed to implement mangrove afforestation in the identified areas of Kaluveli waters wherein the fishing harbour is proposed and accordingly detailed work elements is suggested below towards mitigating the expected impacts arising out of the proposed harbour, if any,:

Objectives

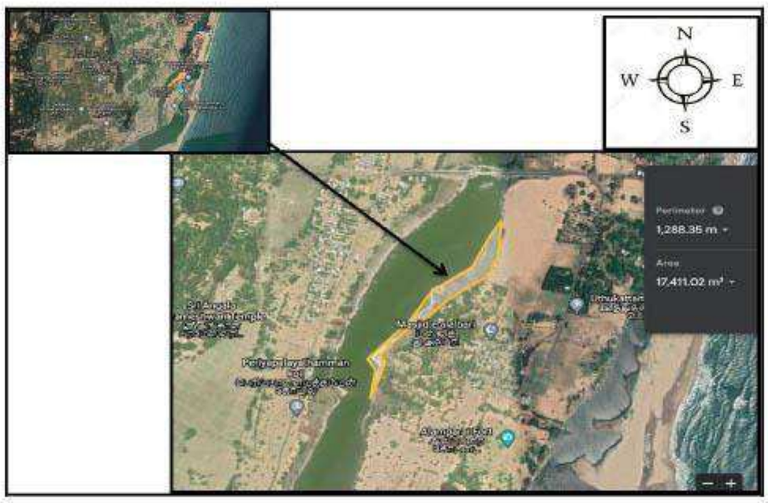
1. To establish mangrove nursery for the afforestation.
2. Establishment of fringe mangrove in the manmade canal
3. To maintain mangrove genetic diversity in the ecosystem

Area

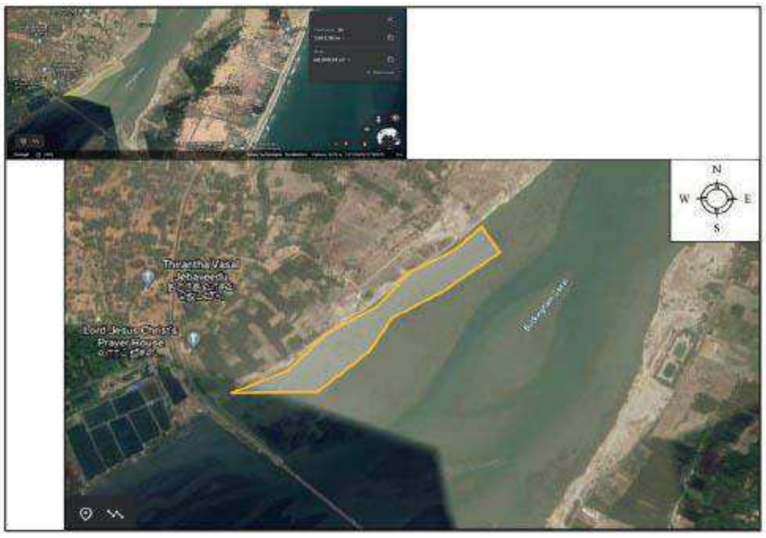
The present proposal is aimed to establish the mangrove nursery and afforestation in and around Kazhuveli, Marakkanam. About 25,000 mangrove samplings belonging to five mangrove species would be established in an area of roughly 9.0 ha.

Project site

Predominantly intertidal areas in Kazhuveli, Marakkanam coastal waters are identified for mangrove plantation.



1.75 ha Intertidal region suitable for mangroves



3.0 ha Intertidal region suitable for mangroves (scattered areas)

4.0 ha Intertidal region suitable for mangroves (scattered areas)

Seed/Propagule source

Seeds and the propagules will be collected from the existing mangrove areas of Pitchavaram, Coleroon, Muthupet and also from various other mangrove forests of India (east and west coasts).

Methodology to be adopted

Centre of Advanced Study in Marine Biology, Annamalai University is implementing mangrove afforestation projects in Tamil Nadu and Puducherry. Some of the regions which are suitable for mangrove plantations are receiving neither the tidal water nor the fresh water run-off due to chronic siltation. Therefore, establishment of manmade canals would facilitate tidal water flow, which is essential requirement for mangrove establishment. The fish bone shape canal method of mangrove restoration will be adopted for the elevated or silted sites. Open intertidal areas would be planted by the mangrove samplings/ propagules directly.

Candidate Species for Nursery

The following species are proposed for raising in the Nursery for the afforestation programme:

1. *Rhizophora apiculata*
2. *R. mucranata*
3. *Avicennia marina*
4. *A. officinalis*
5. *Exocaria agallocha*

To maintain the genetic diversity in the ecosystem, the following species would also be planted along with the above said candidate species, and these will be selected from the different mangrove ecosystem of India.

1. *Agiceras* sp

2. *Bruguira* sp

3. *Xylocarpus* sp

Nursery techniques

S. No	Techniques	Species	Remarks
1	Poly-bag nursery	*A. marina, A. officinalis, B. cylinrica, E. agallocha. Rhizophora apiculata* and *R. mucronata*	The growth of the plants will be faster in the poly-bag type of nurseries.
2	Air layering	*E. agallocha*	Due to poor seed germination, this particular species would be air-layered from the main tree from Pichavaram.

Accordingly, the work elements are given below. To start with the area would be demarcated with GPS co-ordinates for site measurement.

Component 1:

Activity 1.1 Site selection

Activity 1.2. Land leveling and fencing

Activity 1.3. Boundary demarcation

Component 2. Nursery establishment

Activity 2.1 Nursery (Farm yard manure and red soil)

Activity.2. 2.Propagule/ seed collection

Activity 2. 3. Seed rising in pocket or raised bed

Component 3. Canal digging

Activity 2.1. Layout design

Activity 2.2. Canal digging

Component 4. Planting Mangrove seeds

Activity 3.1. Collection of propagules/seeds
Activity 3.2. Planting of seeds
Activity 3.3. Casualty replacement

Component 5. Post Project management

Activity 4.1. Growth monitoring of saplings
Activity 4.2. Casualty replacement

Limitations

The following problems will be anticipated and are to be tackled during the nursery and plantation sites.

1. Top dying
2. Scale insect infection
3. Defoliage due to caterpillar
4. Bacterial blight
5. Root rot disease
6. Soil erosion (due to heavy flooding)

3. Turtle Conservation

Turtles are one of the planet's oldest animals, dating back to the time of dinosaurs, yet their existence is under threat. The entire population of sea turtle species plays an important role in the marine ecosystems by controlling the prey species, providing food for larger predators and they also act as nutrient transporters between the sea and land. In the absence of sea turtles, the health and sustainability of marine as well as coastal ecosystems will be adversely affected. Sea turtles are air-breathing reptiles that spend most of their lives in the ocean. Sea turtles grow slowly and are believed to have a long life span. After male and female sea turtles gather near the nesting beaches early in the season to mate, the females travel to the beach to deposit up to ten clutches of eggs during one season. After hatching, males spend their entire lives at sea. Female sea turtles must periodically return to sandy beaches to lay eggs. When the females awkwardly lumber ashore to nest, they are near-sighted and virtually defenseless. During the nesting process, which can last up to three hours, the female drags herself ashore and crawls to a point above the high-tide line. With her front flippers, she pushes sand away to form a "body pit," digs an "egg cavity" inside the pit with her rear flippers, lays approximately one hundred eggs in the cavity, and then pushes the sand back into the cavity with her rear flippers. Before returning to the surf, she throws sand around the area with her front flippers to conceal the nesting site. After leaving the eggs to incubate in the warm sand, the female never returns to the nest.

After an incubation period of about two months, the sea turtles hatch. Seven days later, the hatchlings burst from the nest during the night and naturally get attracted to the bright sky over the water, and make a mad dash towards the sea. Once they reach maturity, the hatchlings move to permanent feeding grounds. Studies have shown that female turtles reach maturity after 15-20 years and come back to the same beach, which they had left as hatchlings, to lay eggs. They use geo-magnetic field intensity imprint to return to the same shore.

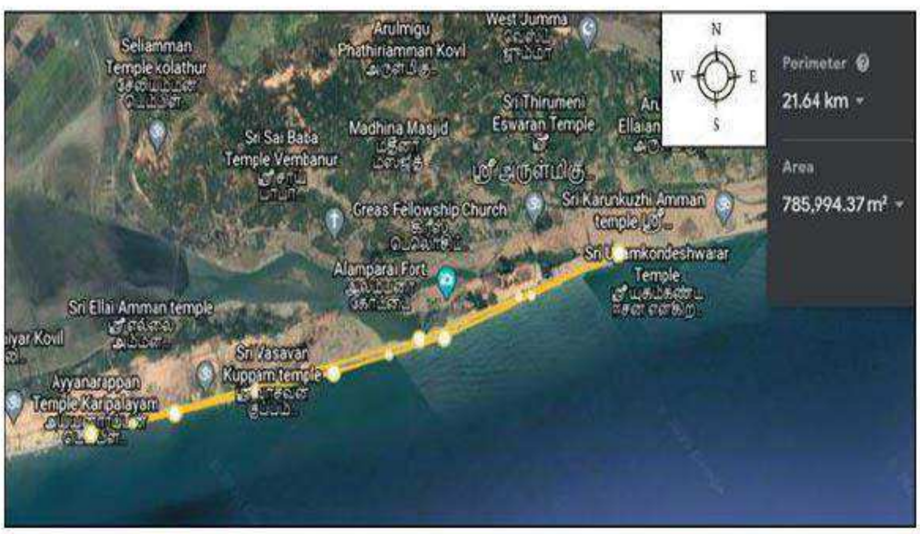
Olive ridley (*Lepidochelys olivacea*)

Status of marine turtle species in India

The following five of the seven species of sea turtles found worldwide are reported to occur in Indian coastal waters and the Bay Islands. They are Olive ridley *(Lepidochelys olivacea),* Green *(Chelonia mydas),* Hawksbill *(Eretmochelys imbricata),* Leatherback *(Dermochelys coriacea)* and Loggerhead *(Caretta caretta).* Barring Loggerhead, the remaining four species nest along the Indian coastline. However, Olive ridley is the most abundant species, among the sea turtles, that is found in India and is well known for its annual mass nesting at Gahirmatha coast, Orissa, other coastal regions including Tamil Nadu beaches were recorded sporadically nesting habitat. The largest nesting aggregation in the world occurs in the Indian Ocean along the northeast coast of India (Orissa), where in 1991 over 600,000 turtles nested in a single week (Mrosovsky1993). All the five species of sea turtles that occur in Indian coastal waters are legally protected under Schedule- I of the Indian Wildlife Protection Act (1972). The *olive ridley* species is listed as endangered by the IUCN.

Status of turtle nesting in Kaluveli beach

According to personal Interview with local inhabitants, nesting occurs (roughly 40-70 nestings) at both north and southern side of river mouth every year in the region (5 km radius). The Forest department of the State Government maintains the data regarding turtle nesting along the coast. Every year, the sporadic nesting of *Lepidochelys olivacea* turtle is found in this region. A female lays about 120 to 140 eggs in a pit. The incubation period for the eggs to hatch out is about 40 to 60 days with a hatching rate of over 95%. The domestic and wild animals pose a threat to the eggs and the hatchlings in the nesting sites. Further, dead carcasses were observed during our survey and further investigation on this with locals revealed that about 70 to 80 cases of incidental mortality of mature Turtles happen every year in this region as they get entangled in the gill and trawl nets operated in this region. As a whole, the nesting activities in the area surrounding the proposed site are very sporadic and meager in number compared to the Gahirmatha coast of Orissa, where the intensity of nesting is high. Based on the present survey and secondary data including personal interview with locals intermittent nesting occurs along the Kaluveli beach and in order to conserve them, the following mitigating measures are suggested towards promotion of turtle nesting:



Turtle nesting grounds in 10 km beach (either side of mouth) area of Kaluveli coast

Measures to maintain the Beaches/Sand Dunes and to promote Turtle Nesting

- ✓ The fixture will be mounted as low as possible to minimize light trespass and the lowest amount of light needed for the task shall be used.
- ✓ Long wavelength lights will be used wherever possible. Low pressure sodium (LPS) lights are considered more desirable than HPS sources. Short wavelength (blue) and broad spectrum sources such as metal halide, mercury vapour, fluorescent or halogen lights will be avoided.
- ✓ Amber filters on HPS lights will be used if HPS lights use cannot be avoided,
- ✓ White lights that emit ultraviolet light will not be used.
- ✓ Strong blue or green spectral elements (e.g. mercury vapour lights) will be limited as far as possible.
- ✓ Lights will be directed downward and will be shielded to avoid overhead glow on cloudy nights
- ✓ To mitigate the erosion related issues, sand by passing / Beach nourishment is considered as one way to mitigate erosion.
- ✓ Dredging should be carried out during non-nesting season.
- ✓ The vegetation to be carried out in the region should comprise only the native species.
- ✓ Facilitate the fisherman to attach Turtle excluding device (TED) to the trawl net to minimize the accidental catch of turtles.
- ✓ The extraction of sand from the coastal line or beaches alters the topography affecting the vegetation, sand dunes and thus the natural habitat of the Turtles and therefore it will be strictly prohibited.
- ✓ Awareness programmes for local fisher population, company labourers and employees shall be undertaken to highlight sea turtle conservation. Awareness regarding fisheries related issues is also necessary among fishing community. Incidental capture of turtles in shrimp trawls and gill nets account for more deaths than all other human activities combined. In addition to the trawl entanglement, sea turtles have been killed after

becoming entangled in other types of fishing gear, such as, gill nets, long lines (hook and line), and lobster or crab pot lines. Creation of awareness among villagers and fishermen shall be undertaken as part of conservation measures.

Alternative and additional livelihood options

Mud crab fattening

Water crab or post moult crab represents a stage in crab's life cycle. During the catch the fishers used to get water crabs every day which fetches cheaper rates as it contains more of water than flesh. This reduces the profit of the fishers. Instead, in the present intervention, the post-moult or water crabs caught by the fishers would be kept in captivity (cage/pen) for a short period of 20- 30 days until they 'flesh out' or normal crabs. Since the fattening period is less, the crabs can be fed with dry and trash fish which is available in the same location. Multiple market and buy pack arrangement will be made with crab collector, buyers and exporters, so that the regular raw material flow will be facilitated.

Sea cage culture of finfish

Aquaculture practices offer best economic returns to the fish farmers and help to reduce fishing pressure from the wild. Fish culture is not popular in the proposed region and therefore there is lot of scope for aquaculture of finfish, lobster in the area. The government may encourage the aquaculture practices of finfish especially seabass, Lates calcarifer and Cobia (Rachycentron canadum) in the area. Seabass and cobia have great demand in the international and domestic markets. Sea cage culture of these finfishes will bring in rapid changes in terms of fish production and economic activity of fishermen in the area. Training has to be imparted to the fisher-folk for the finfish culture.

Rope/ Raft culture of mussel:

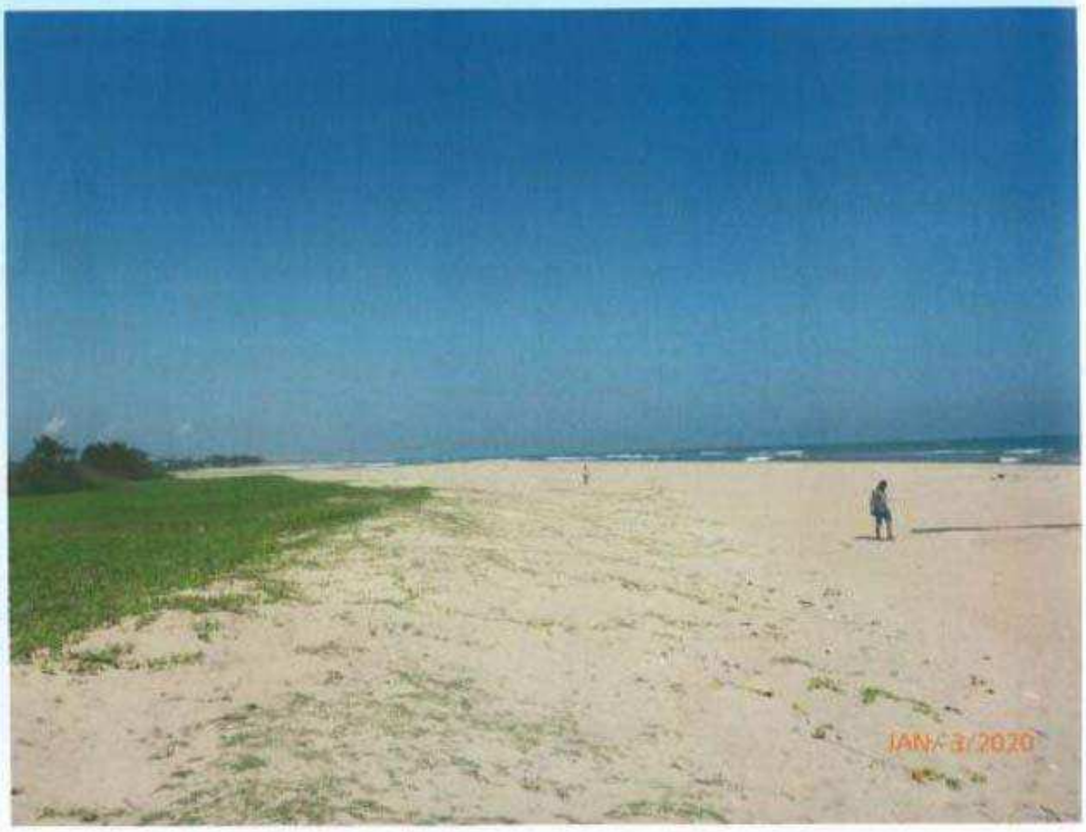
They naturally attach to any substrate. Rope and raft culture techniques have been perfected in India. The yield through rope and raft culture will be many folds. Rope culture of mussel is widely adopted in Northern Kerala. The mussel grows to 80-100 mm size within 6 months of culture period and it is estimated that around 2 lakhs mussels can be harvested from 400 m^2. The commercial mussel culture practices can be encouraged in the coastal area.

ANNEXURE-9

HIGH TIDE LINE, LOW TIDE LINE AND COASTAL REGULATION ZONE FOR THE PROPOSED DEVELOPMENT OF FISHING HARBOURS AT ALAMPARAIKUPPAM AND AZHAGANKUPPAM, KANCHEEPURAM & VILLUPURAM DISTRICTS, TAMIL NADU

for

M/s DHI (India) Water & Environment Pvt. Ltd.



Prepared By

National Centre for Sustainable Coastal Management
Ministry of Environment, Forest & Climate Change
Government of India

February 2020

HIGH TIDE LINE, LOW TIDE LINE AND COASTAL REGULATION ZONE FOR THE PROPOSED DEVELOPMENT OF FISHING HARBOURS AT ALAMPARAIKUPPAM AND AZHAGANKUPPAM, KANCHEEPURAM & VILLUPURAM DISTRICTS, TAMIL NADU

for

M/s DHI (India) Water & Environment Pvt. Ltd.

Prepared By

NCSCM

National Centre for Sustainable Coastal Management
Ministry of Environment, Forest & Climate Change
Government of India

February 2020

DOCUMENTATION SHEET

1	Authorised Institute with Letter No. & Date	National Centre for Sustainable Coastal Management J-17011/8/92-IA-III dt 14th March, 2014
2	Report No.	NCSCM/GEO/CRZ/2020/06
3	Client's/Institute Name	M/s DHI (India) Water & Environment Pvt. Ltd.
4	Authors Investigator Co-investigator Project Fellow	 Badarees KO Manik Mahapatra Vimal K C, Balaguru B, Soundararajan K
5	Type of Report & Map	CRZ Status Report with 1:4,000 scale CRZ map
6	Title	HIGH TIDE LINE, LOW TIDE LINE AND COASTAL REGULATION ZONE FOR THE PROPOSED DEVELOPMENT OF FISHING HARBOURS AT ALAMPARAIKUPPAM AND AZHAGANKUPPAM, KANCHEEPURAM & VILLUPURAM DISTRICTS, TAMIL NADU
7	Key words	Coastal Regulation Zone, Cadastral Map, Scale 1:4000, Landuse, High Tide Line (HTL), Low Tide Line (LTL), CRZ IA, CRZ IB, CRZ II, CRZ III, CRZ IVA, CRZ IVB.
8	Abstract	The Department of Fisheries, Govt. of Tamil Nadu proposed to construct Fishing Harbour in Kaluveli creek at Alamparaikuppam in Kancheepuram district and Azhagankuppam in Villupuram district of Tamil Nadu state. In this regard, Department of Fisheries has appointed DHI (India) Water & Environment Pvt. Ltd. as a consultant for the required studies and clearances viz. CRZ clearance, Rapid EIA study etc. In line with above M/s DHI (India) Water & Environment Pvt. Ltd. Requested NCSCM, MoEF & CC, Govt. of India, Chennai to prepare project level CRZ map by demarcating the HTL and LTL for the above area. Demarcation of HTL and LTL and identification of CRZ have been carried out in cadastral level to provide detailed information on the CRZ with respect to the proposed project site. The CRZ map has been prepared in accordance with the approved CZMP maps of Tamil Nadu state. The proposed "project site A" falls within the Kottaikadu and Alamparai villages and the proposed activities fall within the CRZ IB, CRZ III and CRZ IVB categories. The proposed project site "B" [Marakkanam (TP)] Fishing Harbour and proposed Road falls within CRZ IB and CRZ II categories. The "proposed project site C" falls where Kaliveli Creek/Tank debouches to sea and the northern arm of the proposed Training Wall falls within CRZ IB, CRZ III and CRZ IVA categories whereas, the proposed southern arm falls within CRZ categories such as CRZ IB, CRZ II and CRZ IVA. The proposed Excavation Area falls within the CRZ categories such as CRZ IB, CRZ II and CRZ III.
9	Distribution Statement	Not for Circulation

CONTENTS

HIGH TIDE LINE, LOW TIDE LINE AND COASTAL REGULATION ZONE FOR THE PROPOSED DEVELOPMENT OF FISHING HARBOURS AT ALAMPARAIKUPPAM AND AZHAGANKUPPAM, KANCHEEPURAM & VILLUPURAM DISTRICTS, TAMIL NADU

1.0 Introduction

The Department of Fisheries, Government of Tamil Nadu proposed to construct Fishing Harbour in Kaluveli creek at Alamparaikuppam in Kancheepuram district and Azhagankuppam in Villupuram district of Tamil Nadu state. In this regard, Department of Fisheries has appointed DHI (India) Water & Environment Private Limited as a consultant for the required studies and clearances viz. CRZ clearance, Rapid EIA study etc. In line with above M/s DHI (India) Water & Environment Pvt. Ltd. requested National Centre for Sustainable Coastal Management (NCSCM), Ministry of Environment, Forest & Climate Change, Government of India, Chennai to prepare project level (1:4000 scale) CRZ map by demarcating the High Tide Line (HTL) and Low Tide Line (LTL) for the above area. Demarcation of HTL and LTL and identification of Coastal Regulation Zone (CRZ) have been carried out in cadastral level to provide detailed information on the CRZ with respect to the proposed project site. CRZ map of 1:4000 scale was prepared by using the field survey conducted during January 2020 to demarcate High Tide Line (HTL) and ecologically sensitive areas.

2.0 Objective

The objectives of the study are:

- Identification and demarcation of HTL and LTL for the proposed project area
- Preparation of CRZ Maps of 1:4000 Scale by demarcating CRZ categories
- CRZ categorization as per CRZ Notifications 2011

3.0 Location

The proposed project site is located in Kaluveli creek bank at Alamparaikuppam in Kancheepuram district and Azhagankuppam in Villupuram district of Tamil Nadu state.

The project site is located within the Lat. Long. of 12°14'33.478"N 79°59'16.282"E and 12°15'55.21"N 80°0'49.487"E (Fig.1).

Fig. 1: Location Map

4.0 Approach & Methodology

The CRZ map is prepared on large scale base maps to facilitate the easy and accurate implementation of CRZ in the field. Digitized Cadastral map is obtained from the Department of Environment, Government of Tamil Nadu as the base map for the present investigation. The HTL/LTL is identified following the guidelines issued by MoEF, Govt. of India.

The key elements of the approach and methodology are:

- Demarcation of HTL based on the Aerial Photo of 2011.
- Identify the HTL based on the geomorphic signature and map the HTL and control points.
- Transfer the HTL to the cadastral map with respect to control point mapped.
- Prepare the CRZ map delineating the HTL, LTL and the CRZ categories.

4.1 Extraction of HTL

Extraction of HTL was carried out using aerial photographs of 2011 at Survey of India and verified in the field. HTL was identified from Aerial photo based on geomorphologic features and other features such as embankments, landward boundaries of tidal flats (MoEF & CC, 2011). The line of monsoon berm crest or boundary perennial vegetation/permanent vegetation forms the HTL along the seacoast.

5.0 Data Source

In addition to the investigation, data from various sources were used for the compilation of the final CRZ map and preparation of the CRZ report. The principal data sources include:

- Hydrographic charts of National Hydrographic Office
- Survey of India Toposheets
- Aerial Photos
- Satellite image

6.0 Tides

Tide is an important parameter that influences the position of HTL. It is also important in determining the landward extent of the reach of seawater into the land along rivers and backwaters. Tidal range data with respect to Chart Datum pertaining to Pondicherry (Lat. 11.56N Long. 79.50E) provided by the National Hydrographic Office, Dehra Dun is given below in Table 1.

Table 1: Tidal range at Pondicherry (Tidal Levels referred to Datum of Sounding) (NHO Chart No. INT 7397 357)

Tide Condition	Height (m)
Mean High Water Spring	1.3
Mean High Water Neap	1.0
Mean Low Water Neap	0.7
Mean Low Water Spring	0.5
Mean Sea Level	0.9

7.0 Field Investigation

Field investigations were carried out during January 2020. HTL was identified from Aerial photo and verified at field based on geomorphologic features and other features such as embankments, landward boundaries of intertidal zone (MoEF & CC, 2011). HTL was plotted with respect to reference points identified in the field as well as Aerial photo and located in the cadastral map. An appraisal of existing land use/landform in the project area was also carried out. The distance and positions of HTL to control points which were extracted from the aerial photographs were verified in the field using high precision Trimble GPS.

8.0 Coastal landuse/landcover

The coastal area is occupied with settlements, agricultural land and infrastructural facilities. The major landuse/landcover is settlements, sand dune, saltpan, mixed vegetation with coconut trees, infrastructure facilities, etc. The seaside has beach with medium to fine-grained sand at some stretches.

9.0 Coastal Regulation Zone and HTL

The Government of India Notification [S.O.19 (E) dated 6.1.2011] under Section 3(1) and Section 3(2)(v) of the Environment (Protection) Act, 1986 and Rule 5(3)(d) of Environment (Protection) Rules, 1986 declares 'the coastal stretches of the country and the water area up to its territorial water limit as Coastal Regulation Zone (CRZ)' (MoEF & CC, 2011). All developmental activities in the CRZ are regulated through the CRZ Notification (MoEF & CC, 2011).

The CRZ, as per CRZ Notification 2011, consists of the following:

1. Land area from High Tide Line (HTL) to 500 m on the landward side along the seafront.
2. Land area from HTL to 100 m or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance up to which development along such tidal influenced water bodies is to be regulated are governed by the distance up to which the tidal effects are experienced which is determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year and distance up to which tidal effects are experienced would be clearly identified and demarcated accordingly in the Coastal Zone Management Plans (CZMPs). The tidally influenced water bodies mean the water bodies influenced by tidal effects from the sea, in the bays, estuaries, rivers, creeks, backwaters, lagoons, ponds connected to the sea or creeks and the like.
3. Land area falling between the hazard line and 500 m from HTL on the landward side, in case of the seafront and between the hazard line and 100 m line in case of the tidally influenced water body. The word 'hazard line' denotes the line demarcated by Ministry of Environment and Forests & Climate Change (MoEF & CC) through the Survey of India (SOI) taking into account tides, waves, sea level rise and shoreline changes.
4. Land area between HTL and Low Tide Line (LTL) which will be termed as the intertidal zone.

5. The water and the bed area from the LTL to the territorial water limit (12 Nm) in case of sea and the water and the bed area from LTL at the bank to the LTL on the opposite side of the bank, of the tidal influenced water bodies.

According to the CRZ Notification 2011, the tidally influenced water body has been defined as bays, estuaries, rivers, creeks, backwaters, lagoons and ponds connected to the sea or creeks and the like. The distance from the HTL shall apply to both sides of the tidally influenced water body. The CRZ Notification categorizes Coastal Regulation Zones as CRZ I, CRZ II, CRZ III and CRZ IV based on whether the area is ecologically sensitive, developed, undeveloped or water body and its bed. Ecologically sensitive and important areas and the intertidal zone constitute CRZ I. Sensitive ecosystems such as mangroves, corals, turtle nesting grounds, salt marshes, mudflats, etc., are classified as CRZ IA. The Intertidal zone is CRZ IB. The areas that have already been developed up to or close to the shoreline are categorized as CRZ II. Areas that are relatively undisturbed belong to CRZ III. The water area and the bed constitute CRZ IV.

The CRZ Notification of 2011 has also defined Critical Vulnerable Coastal Areas (CVCA), which includes Sunderbans, and other identified ecological important areas including the Gulf of Khambhat and Gulf of Kachchh in Gujarat. It is to prepare Integrated Management Plans (IMPs) for such CVCA keeping in view of the conservation and management of mangroves, needs of local communities such as dispensaries, schools, public rain shelter, community toilets, bridges, roads, jetties, water supply, drainage, sewerage and the impact of sea level rise and other natural disasters. The IMPs will be prepared as per the guidelines of the MoEF & CC.

The Coastal Zone Management Plan (CZMP) prepared based on CRZ Notification 2011 and approved in 2018 is valid for Tamil Nadu state for the approval CRZ projects.

10.0 Status of the proposed constructions and Coastal Regulation Zone (CRZ) categories

Project Site A: As per the Sheet No. D 44 T 16/NE, D 44 U 3/SW and Map Numbers TN 95, TN 98 of approved CZMP prepared as per CRZ Notification 2011, the proposed "project site A" falls within the Kottaikadu and Alamparai villages and the proposed activities fall within the CRZ IB, CRZ III (No Development Zone) and CRZ IVB (Creek) categories (Refer Fig. 2). During the field visit at Project site "A" on January 2020 it is observed that few countable mangroves of 1 to 2 feet height were present within the intertidal zone.

Project Site B: The proposed project site "B" [Marakkanam (TP)] Fishing Harbour and proposed Road falls within CRZ IB (Intertidal Zone) and CRZ II categories (Refer Fig. 2).

Project Site C: The "proposed project site C" falls where Kaliveli Creek/Tank debouches to sea and the northern arm of the proposed Training Wall falls within CRZ IB (Intertidal Zone), CRZ III (No Development Zone) and CRZ IVA (Bay of Bengal Sea) categories whereas, the proposed southern arm falls within CRZ categories such as CRZ IB (Intertidal Zone), CRZ II and CRZ IVA (Bay of Bengal Sea) (Refer Fig. 2). The proposed Excavation Area falls within the CRZ categories such as CRZ IB (Intertidal Zone), CRZ II and CRZ III (No Development Zone) (Refer Fig. 2). The CRZ map has been prepared in accordance with the approved CZMP maps of Tamil Nadu state. The proposed project site falls within the Sheet Numbers D 44 T 16/NE, D 44 U 3/SW and Map Numbers TN 95, TN 98 of approved CZMP prepared as per CRZ Notification 2011.

10.1 Major CRZ categories around the project sites

The major CRZ categories around the project site within 7 KM radius is CRZ IA (Mangroves, Sand Dune and Archaeological Importance and Heritage Sites), CRZ IB (Intertidal Zone and Saltpan or Aquaculture), CRZ II, CRZ III (No Development Zone and 200 to 500 m from HTL), CRZ IVA (Bay of Bengal Sea) and CRZ IVB (Fig. 3). The land area between HTL and LTL is termed as the intertidal zone (CRZ IB). Being a developed area the area between High Tide Line to 500 m along sea coast and the area between High Tide Line to 100 m or width of the creek on the landward side CRZ area is classified under the CRZ II category. Being a rural or undeveloped area the area between High Tide Line to 200 m is classified as No Development Zone and 200 m to 500 m CRZ area classified under the CRZ III category along sea coast. The water area and the bed constitute CRZ IV. The seasonal beach is CRZ IB. A CRZ map covering about 7 Km radius of the project site representing CRZ categories is given in figure 3.

11. 0 Summary and Conclusion

- The HTL, LTL and CRZ categories are presented in 1:4000 scale maps.

- The HTL and LTL are demarcated from aerial photographs/satellite images by taking into consideration different signatures such as boundaries of embankments, vegetation and bunds as existed at the aerial photo/satellite image where verified in the field.

- The proposed project sites (A, B and C) falls within the CRZ categories such as CRZ IB (Intertidal Zone), CRZ II, CRZ III (No Development Zone), CRZ IVA and CRZ IVB (Refer Fig. 2).

- The northern arm of the proposed Training Wall falls within CRZ IB (Intertidal Zone), CRZ III (No Development Zone) and CRZ IVA (Bay of Bengal Sea) categories whereas, the proposed southern arm falls within CRZ categories such as CRZ IB, CRZ II and CRZ IVA (Refer Fig. 2).

- The proposed Excavation Area falls within the CRZ categories such as CRZ IB, CRZ II and CRZ III (No Development Zone) (Refer Fig. 2).

- Few countable mangroves of 1 to 2 feet height are present in the proposed project site A.

- The CRZ map has been prepared in accordance with the approved CZMP maps of Tamil Nadu state. The proposed project site falls within the Sheet Numbers D 44 T 16/NE, D 44 U 3/SW and Map Numbers TN 95, TN 98 of approved CZMP prepared as per CRZ Notification 2011.

REFERENCES

MoEF, 1991. Notification No.S.0114 dated 19th February, 1991, Ministry of Environment and Forest, Government of India, New Delhi.

MoEF, 1996. Letter No. Letter No.J-17011/8/95-IA-111, dated 27-9-1996 dated 27th September 1996 to the Chief Secretary, Govt. of Maharashtra. Ministry of Environment and Forest, Government of India, New Delhi.

MoEF, 2011. Notification No. S.O.19 (E) dated 6.1.2011, Ministry of Environment and Forest, Government of India, New Delhi.

NHO, 2011. Hydrographic Chart no INT 7397 357 – Point Calimere to Chennai. National Hydrographic Office, Dehra Dun, 2011.

PLATES

Plate 1: Proposed Fishing Harbour site at Alamparaikuppam (Proposed site A)

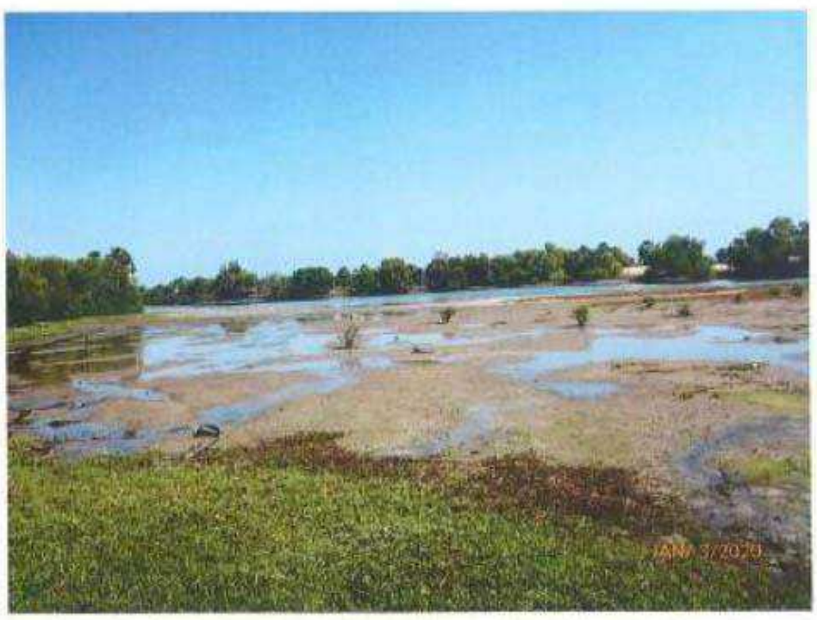


Plate 2: Scattered Mangroves along "Project site A"

Plate 3: Sand dune behind the proposed "Project site B"

Plate 4: A View of Proposed Training Wall Location at "Project Site C"

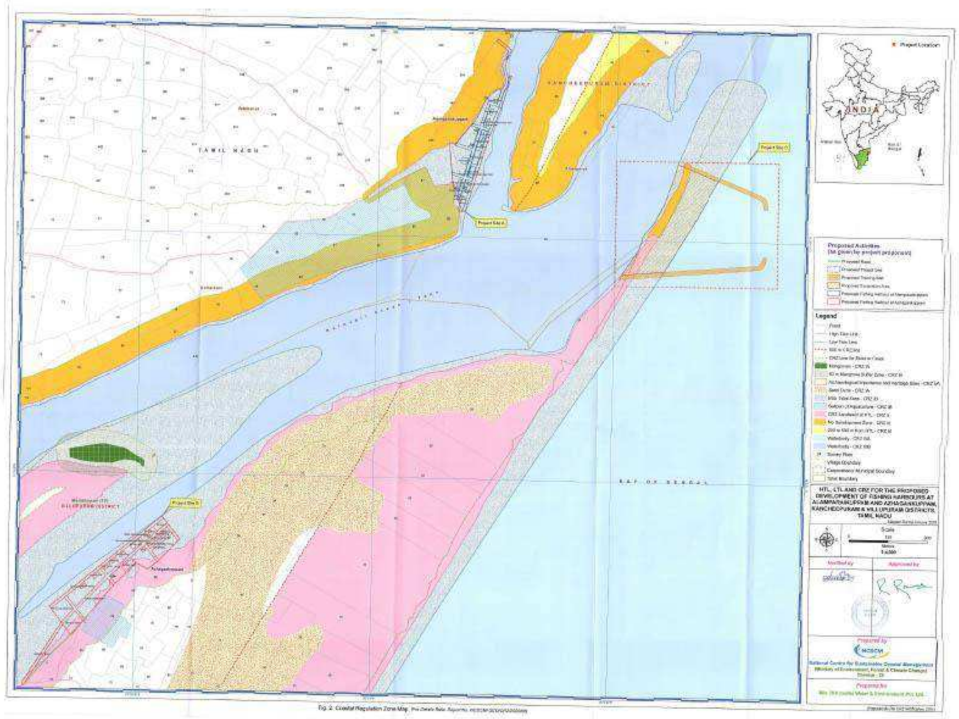


Fig. 2: Coastal Regulation Zone Map

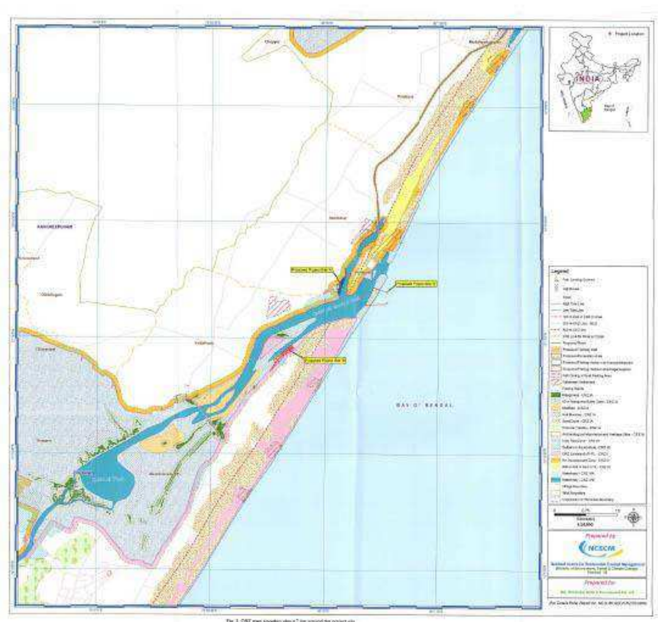


Fig. 3: CRZ map showing about 7 km around the project site

ANNEXURE-10

(257)

E,CC&F (FR.5) Dept.,

Minutes of the Meeting on Kazhuveli Wetland in Villupuram District held on 15.11.2021 at Secretariat

A Review Meeting on Kazhuveli Wetland in Villupuram District on a proposal to notify it as Birds Sanctuary was held on 15.11.2021 under the Chairmanship of the Chief Secretary at the Secretariat. The list of participants in the meeting is annexed to the minutes.

The Principal Secretary, Environment, Climate Change and Forest Department briefed about the Kazhuveli Wetland and highlighted the significant ecological value of this wetland.

The District Forest Officer, Villupuram made a presentation on Kazhuveli wetland and highlighted the following.

1. A proposal along with recommendations of the District Collector, Villupuram to notify Kazhuveli wetland as Bird Sanctuary under the provisions of the Wildlife (Protection) Act, 1972

2. Kazhuveli is identified as one of the wetlands of international importance.

3. In the year 2001, an extent of 4,722 ha in Kazhuveli wetland was notified under Sec 26 of the Tamil Nadu Forest Act (1882).

4. It is notified under the Coastal Regulation Zone Notification, 2011 as CRZ - 1A1A under the Environment (Protection)Act, 1986, which means coastal zone of environmentally most critical area.

5. Kazhuveli wetland is included by Salim Ali Centre for Ornithology and Natural History (SACON) among one of the 141 natural prioritized wet lands in Tamil Nadu.

6. It is an important stop-over and breeding ground for migratory birds in Central Asian Flyway.

7. The diverse habitat in the wetland supports different species of birds like shore birds, wading birds, birds on floating vegetation and open water birds.

8. Major land use pattern around the wetland comprises of agricultural farms and coconut plantations. In addition to this, there are shrimp farms &hatcheries, aquaculture and salt pan etc.,

9. There are no major polluting industries or mining around the proposed Bird Sanctuary.

10. The illegal shrimp farms and encroachments were evicted in 2016 based on NGT direction.

The District Forest Officer, Villupuram concluded the presentation by elaborating on directions issued earlier by Honourable High Court and Green Tribunal to protect Kazhuveli wetland.

He further informed that a proposal has been received from the Executive Engineer, Water Resources Department for diversion of 73.75 ha of forest land in Kazhuveli for storage of fresh water. The proposed construction of check dam will prevent intrusion of sea water to Kazhuveli wetland and also will adversely affect local biodiversity in the natural habitat which needs to be looked into. Chief Secretary asked Principal Secretary, Environment, Climate Change and Forest Department to take up the matter separately with Addl. Chief Secretary, Water Resource Department.

The Addl. Chief Secretary, Animal Husbandry, Dairying, Fisheries and Fishermen Welfare Department appraised that the ongoing project in Yedayanthittu estuary is at about 21 km away from Kazhuveli. The declaration of wetland will therefore not impact the project. He also presented maps showing the ongoing project work.

After discussion the following decisions were taken,

1. Action must be taken to declare Kazhuvelli Wetland as Bird Sanctuary (a Protected Area) under the relevant Act.

2. A Master Plan or Management Plan needs to be prepared to protect the natural habitat of Kazhuveli.

(259)

3. The status of natural flora and fauna of Kazhuveli should be studied.

4. A Plan needs to be prepared to augment the natural regeneration of local flora and fauna.

5. Fencing is needed around the boundaries to protect the wetland. A proposal for financial sanction can be moved in this regard.

6. The project for prevention of intrusion of salt water to Kazhuveli and conversion of Kazhuveli to a freshwater body and its effects and impact on habitat has to be discussed with the concerned Department with the District Collector.

7. Meetings and awareness programmes involving local fishermen communities should be conducted to take them into confidence in protecting Kazhuveli.

8. Dumping of garbage and effluents in Kazhuveli needs to be prevented. Once the place is declared as bird sanctuary, field staff should be posted to protect the area.

The meeting ended with a vote of thanks to the Chair and participants.

V. IRAI ANBU
Chief Secretary to Government

//True Copy//

B. Sulochana
Section Officer
8/6/17

261

Annexure – List of Participants

1. Additional Chief Secretary to Government, Animal Husbandry, Dairying and Fisheries Welfare Department
2. Principal Secretary, Environment, Climate Change and Forest Department
3. Principal Chief Conservator of Forests & Chief Wildlife Warden
4. Special Secretary(Forests), Environment, Climate Change and Forest Department
5. Conservator of Forests, Villupuram Forest Circle
6. District Forest Officer, Villupuram District
7. Executive Engineer, Fisheries and Fishermen Welfare Department

****

ANNEXURE-11

CHAPTER-4

HYDROLOGIC MODEL SIMULATION AND RESULTS

4.1 MODELLING OF HYDROLOGICAL SYSTEM USING WEAP

WEAP:

WEAP ("Water Evaluation And Planning" system) is a user-friendly software tool that takes an integrated approach to water resources planning.The WEAP, aims to incorporate these issues into a practical yet robust tool for integrated water resources planning. WEAP is developed by the Stockholm Environment Institute's U.S. Center.

Catchment:

Catchment of individual tanks and total catchment of Kazhuveli Lake were estimated through watershed delineation of Digital Elevation Model with 3 arc second resolution in WEAP.

Storage Capacity of Kazhuveli Lake:

Storage capacity of the lake was estimated by contours with 0.5 m intervals. The annual storage capacity was estimated as 6.20 tmc with consideration of two fillings. Contours were drawn by 30 m resolution DEM through ArcGIS tool.

The annual storage capacity of storage units of the hydrologic system were estimated with respect to two fillings per year. Storage capacity of all tanks which are maintaining by PWD was accounted for surface runoff estimation.

Climate Data:

The climate data were used from WEAP server data (Princeton 0.25 deg grid) and WRD field observations. The monthly data was processed under the water budgeting principle.

Table 4.1 Rainfall Data Used

Sl.no	Water Year June	Water Year May	RF [mm]
1	1970	1971	1319
2	1971	1972	1123
3	1972	1973	1379
4	1973	1974	1064
5	1974	1975	746
6	1975	1976	1306
7	1976	1977	1677
8	1977	1978	1699
9	1978	1979	1469
10	1979	1980	1170
11	1980	1981	1033
12	1981	1982	1265
13	1982	1983	1000
14	1983	1984	1322
15	1984	1985	1056
16	1985	1986	1953
17	1986	1987	958
18	1987	1988	1051
19	1988	1989	1492
20	1989	1990	1505
21	1990	1991	1139
22	1991	1992	1163
23	1992	1993	1034
24	1993	1994	1354
25	1994	1995	1373
26	1995	1996	1043
27	1996	1997	1153
28	1997	1998	1550
29	1998	1999	1365
30	1999	2000	917
31	2000	2001	1127
32	2001	2002	1420
33	2002	2003	1157
34	2003	2004	1241
35	2004	2005	1241
36	2005	2006	1840
37	2006	2007	1202
38	2007	2008	1609
39	2008	2009	1530
40	2009	2010	1105
41	2010	2011	1552
42	2011	2012	1524
43	2012	2013	650
44	2013	2014	960
45	2014	2015	1250
46	2015	2016	1995

Sl.no	Water Year		RF [mm]
	June	May	
47	2016	2017	750
48	2017	2018	1240
49	2018	2019	996

4.2 SIMULATION

Rainfall Runoff Method (Soil Moisture Method):

The Soil Moisture method is more complex, representing the catchment with two soil layers, as well as the potential for snow accumulation. In the upper soil layer, it simulates evapotranspiration considering rainfall and irrigation on agricultural and non-agricultural land, runoff and shallow interflow, and changes in soil moisture. This method allows for the characterization of land use and/or soil type impacts to these processes. Base flow routing to the river and soil moisture changes are simulated in the lower soil layer. Correspondingly, the Soil Moisture Method requires more extensive soil and climate parameterization to simulate these processes.

Mass balance equations are the foundation of WEAP's monthly water accounting: total inflows equal total outflows, net of any change in storage (in reservoirs, aquifers and catchment soil moisture). Every node and link in WEAP has a mass balance equation, and some have additional equations which constrain their flows (e.g., inflow to a demand site cannot exceed its supply requirement; outflows from an aquifer cannot exceed its maximum withdrawal).

4.3 RESULTS AND INTERPRETATION

ESTIMATION OF YIELD:

Table 4.2Surface Runoff

Sl.no	Year		Rain fall [mm]	Surface Runoff [MCft]	Rank	Remarks
	FROM JUNE	TO MAY				

Sl.no	Year		Rain fall [mm]	Surface Runoff [MCft]	Rank	Remarks
	FROM JUNE	TO MAY				
1	1970	1971	1319	3387.42	13	
2	1971	1972	1123	1170.75	32	
3	1972	1973	1379	3578.94	12	
4	1973	1974	1064	986.52	40	
5	1974	1975	746	50.00	49	LOWEST
6	1975	1976	1306	2850.03	18	
7	1976	1977	1677	6844.46	7	
8	1977	1978	1699	9109.53	4	
9	1978	1979	1469	3667.65	11	
10	1979	1980	1170	2569.48	21	
11	1980	1981	1033	833.28	43	
12	1981	1982	1265	2583.13	20	
13	1982	1983	1000	1123.99	34	
14	1983	1984	1322	1776.44	27	
15	1984	1985	1056	1015.39	37	75% DEPENDABLE
16	1985	1986	1953	9508.62	3	
17	1986	1987	958	853.30	41	
18	1987	1988	1051	1584.17	31	
19	1988	1989	1492	3936.11	10	
20	1989	1990	1505	2271.06	25	
21	1990	1991	1139	2539.79	22	
22	1991	1992	1163	1616.21	29	
23	1992	1993	1034	1094.12	36	
24	1993	1994	1354	3074.47	15	
25	1994	1995	1373	2196.55	26	
26	1995	1996	1043	1587.85	30	
27	1996	1997	1153	2538.19	23	
28	1997	1998	1550	6915.47	5	
29	1998	1999	1365	2892.91	17	
30	1999	2000	917	446.16	45	

Sl.no	Year		Rain fall [mm]	Surface Runoff [MCft]	Rank	Remarks
	FROM JUNE	TO MAY				
31	2000	2001	1127	1117.27	35	
32	2001	2002	1420	2834.59	19	
33	2002	2003	1157	2473.80	24	
34	2003	2004	1241	852.41	42	
35	2004	2005	1241	2959.48	16	
36	2005	2006	1840	10690.24	2	
37	2006	2007	1202	1744.06	28	
38	2007	2008	1609	3381.06	14	
39	2008	2009	1530	6901.63	6	
40	2009	2010	1105	1130.60	33	
41	2010	2011	1552	6665.50	8	
42	2011	2012	1524	5501.85	9	
43	2012	2013	650	75.00	48	
44	2013	2014	960	375.55	46	
45	2014	2015	1250	997.35	38	
46	2015	2016	1995	12010.34	1	HIGHEST
47	2016	2017	750	101.55	47	
48	2017	2018	1240	991.55	39	
49	2018	2019	996	540.42	44	

COMPUTATION OF PEAK DISCHARGE:

The peak discharge at the upstream of the Kazhuveli lake was estimated through the Ryves formula as follows

Ryves Formula:

$Q = CA^{2/3} - ca^{2/3}$

C= 1000 c=500

A= Total Area of Catchment

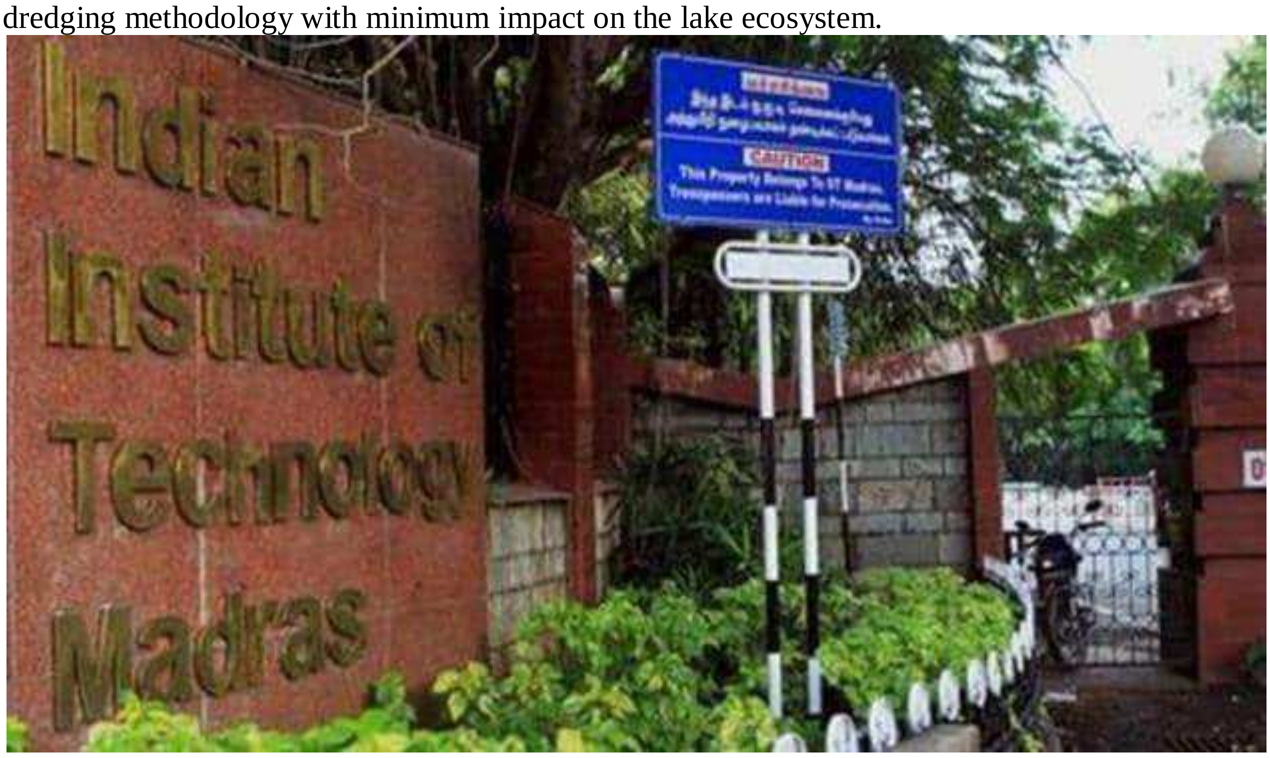
a= Total intercepted Catchment

Estimated Peak Discharge Q = 30000 cusec

ANNEXURE-12

IIT Madras dredging methodology helps Odisha's Chilika Lake to triple Irrawaddy Dolphin population

The searchers conducted geotechnical, hydraulic and satellite imagery studies and developed a dredging methodology with minimum impact on the lake ecosystem.



Indian Institute of Technology Madras.(PTI)

A research project by the Indian Institute of Technology (IIT) Madras has helped Odisha's Chilika lake, Asia's largest brackish water body, in tripling the population of the Irrawaddy dolphins.

The searchers conducted geotechnical, hydraulic and satellite imagery studies and developed a dredging methodology with minimum impact on the lake ecosystem. The process of dredging consists of the excavation (loosening or dislodging) of the material from the bottom, removal of the loosened material to the dredge vessel and ultimately transportation of the material to the placement area.

The intervention by the premiere institute also benefitted the over 200,000 fishermen living in 132 villages **as it resulted in a seven-fold increase of fish catch and tourists to co-exist with the lake ecosystem with minimal disturbance to the environment**, the team claims.

"Chilika Lagoon is over 4,000 years old and spread over the Puri, Khurda and Ganjam districts of Odisha. The highly productive ecosystem of the lake supports the livelihood for fishermen and also acts as drainage for Mahanadi river basin," R Sundaravadivelu, Professor at Department of Ocean Engineering, IIT Madras said. "The lake was in a degraded condition and included in the threatened list by Ramsar Convention in 1993. This warranted urgent action for restoration of the lake," he added. "The geotechnical, hydraulic and satellite imagery studies showed the spit of Chilika is constantly changing. The sand bar has been widening, and the position of the mouth constantly shifting, moving generally towards the northeast. The mouth was described as being about 1.5 km wide in 1780 and had decreased to half within forty years in 1820." "It also showed the Chilika lake mouth located originally near Sipakuda in 1800 has gradually shifted in the last 200 years towards the northern side to Arkhakuda," he said.

The IIT Madras team developed the dredging methodology identifying the location of dredging along with disposal and selection of suitable dredger with *minimum impact on the ecosystem. "Based on the outcome of this successful*

hydrological intervention, the flood inundation and freshwater weeds are reduced. The hydrological intervention restored the lake ecosystem and ameliorated the biodiversity. The fish production increased 7-fold and the ***population of highly threatened Irrawaddy dolphin increased," Sundaravadivelu*** **said.**

"The enhancement of fishery resources and the increase of population of Irrawaddy dolphin promoted ecotourism which immensely benefitted the local fishers," he added.

Restored at a cost of ₹10 crore by opening the mouth and other related works in six months', the lake is now off the threatened list (Montreux record).

The Chilika Lake Authority has developed an Ecosystem Health Report Card and periodical monitoring of salinity, fish and dolphin, freshwater weeds, birds and other biological parameters are being carried out.

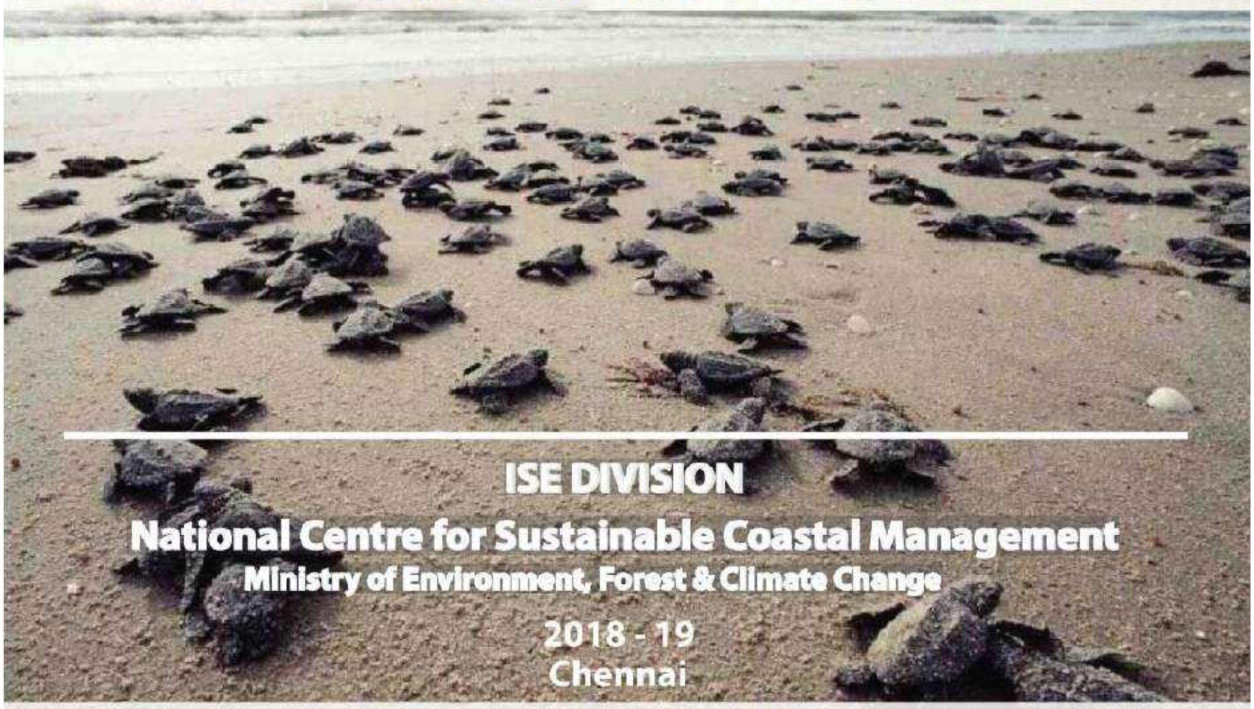
Hindustan Times

Published on May 29, 2020 04:55 PM IST
New Delhi

ASSESSMENT OF COASTAL AND MARINE ECOSYSTEM GOODS AND SERVICES – LINKING COASTAL ZONE MANAGEMENT TO ECOSYSTEM SERVICES IN INDIA

FINAL REPORT

TURTLE NESTING GROUNDS



ISE DIVISION

National Centre for Sustainable Coastal Management

Ministry of Environment, Forest & Climate Change

2018 - 19

Chennai

SOCIETY OF INTEGRATED COASTAL MANAGEMENT

NCSCM

THE WORLD BANK

ASSESSMENT OF COASTAL AND MARINE ECOSYSTEM GOODS AND SERVICES - LINKING COASTAL ZONE MANAGEMENT TO ECOSYSTEM SERVICES IN INDIA

TURTLE NESTING GROUNDS

by

Integrated Social Sciences and Economics (ISE) Division
National Centre for Sustainable Coastal Management
Ministry of Environment, Forest and Climate Change
Government of India

Research Team – Integrated Social Sciences and Economics Division – NCSCM

Dr. D. Asir Ramesh
Dr. L. Muthukrishnan
N. Karthi
S. Dhivya

Data and Knowledge Support - NCSCM

Dr. R. Muruganandam, Geospatial Sciences Division

Guidance

Dr. Purvaja Ramachandran, Division Chair, NCSCM
Dr. Ramesh Ramachandran, Director, NCSCM

Contents

SUMMARY

Sea turtles are ancient reptiles that have changed little over their 150 million year history on Earth. Sea turtles migrate hundreds or even thousands of kilometres between established feeding and breeding sites. All sea turtle species lay their eggs on land, typically on sandy beaches. Turtle nesting grounds are on land, and they are typically sandy beaches. Turtles have various ecological roles, including: nutrient cycling, which is crucial for the coastal ecosystem; and maintenance of sea grass beds, coral reefs and beach dunes. Aside from the obvious ecological services, sea turtles contribute to tourism activities, due to their charismatic nature, yielding great economic benefits.

Turtle nesting grounds have been distributed in 179 sites covering 17,872 ha are located in mainland and island coast of India. In turtle nesting areas, regulation, cultural and supporting services generate economic value than consumptive use. Turtle nesting beaches protect the coastal communities from storm surges, and cyclones. In addition, it acts as an aquifer and source of freshwater to the coastal communities of India. Turtle products such as oil, calipee (cartilage), skin, viscera, shell, and curios are popular among the coastal communities of the world illegal market and it is protected in India. Though marine turtle are protected from consumption in India, to estimate the value of turtle's international market, value of meat and eggs used by coastal communities have been used to value the turtle nesting grounds.

In general, the survival of sea turtle has been threatened by loss of their habitat. Sustainability of turtle population has been pressurized by various anthropogenic activities in turtle nesting sites. It is widely observed that, the turtle population and its nesting beaches are declining due to manmade activities and sea level rise. Quantification of the economic consequences of marine turtle use and conservation could contribute significantly to our understanding of use options and their ecological impacts, and hence further the process of defining adequate management policies. Expressing the economic value of various uses and benefits of turtle nesting grounds shall be a tool to raise awareness and convey its (relative) importance to general public and policy makers.

The use and non-use values of the turtle nesting ground has been estimated at Rs. 45, 68,358 /- yr. /ha. Out of which recreation function shares Rs. 29, 81,237/- yr. /ha. Disturbance regulation and water storage function of turtle nesting ground was estimated at Rs, 1, 17,866/yr./ha, and Rs. 12,61,326/yr./ha respectively. In addition, consumptive value of Rs2, 07,929/ ha, has been incorporated in this study though there is no consumption in India but, it has international market value. The Total Economic Value of turtle nesting ground of India is Rs.7997 Crore. Out of the total benefit from turtle nesting grounds, Andaman and Nicobar islands share Rs.5826 crore followed by Andhra Pradesh Rs. 601 crore. Economic contributions of various States and UTs have been described below.

1. INTRODUCTION

Sea turtles are ancient reptiles that have changed little over their 150 million year history on Earth (Fugazzatto and Behera, 1999). Sea turtles are air-breathing reptiles spending most of their lives at sea. During the breeding/nesting seasons, both sexes typically aggregate in the waters close to the nesting beaches (Hamann etal., 2003). Sea turtles migrate hundreds or even thousands of kilometers between established feeding and breeding sites (Plotkin., 2003). All sea turtle species lay their eggs on land, typically on sandy beaches. The location at which sea turtles lay their eggs is called turtle nesting grounds. Turtles nesting are happening in narrow beaches where it can lay eggs and suitable environment for hatching of young ones. Costa Rica, Nicaragua, Panama, Mexico, Surinam and India are the popular beaches for turtle nesting (National Marine Fisheries Services/US Fish And Wildlife Service., 1996).

Turtle nesting grounds are on land, and they are typically sandy beaches (http://www.biodiversitya-z.org/content/turtle-nesting-site.pdf). The seven different species of sea turtles occupy different, although often overlapping, geographic ranges. In general, sea turtles occupy a wide range of oceanic habitats and will travel widely in their lifetimes (Hawkes etal., 2009). Turtles have various ecological roles, including: nutrient cycling, which is crucial for the coastal ecosystem; and maintenance of sea grass beds, coral reefs and beach dunes (Moran and Bjorndal, 2005, Hannan et al. 2007). Aside from the obvious ecological services, sea turtles contribute to tourism, due to their charismatic nature, yielding great economic benefits (Clevo and Clem, 2001). Marine turtles are highly migratory and represent an open-access resource. Many countries recognize the need to reduce marine turtle mortality from human sources and have provided partial or total legal protection for marine turtles. However, attempts to exclude users and reduce human impacts have met limited success, particularly in countries where funds to enforce restrictive legislation are scarce (Troeng and Drews, 2004).

Rushikulya, Odisha, India

In general, the survival of sea turtle has been threatened by loss of their habitat. It is widely observed that, the turtle population and its nesting beaches are declining due to manmade activities and sea level rise (Fish et al., 2008). IUCN has classified the marine turtle species under red list, endangered and vulnerable species. In India, many turtle species have been protected under Schedule 1 of the Indian Wild Life (Protection) Act, 1972. Party to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), ratified the

Convention on Biological Diversity (CBD) and related treaties, implementing National Biodiversity Act. Areas of turtle nesting site have been classified under sanctuaries and National marine parks. Appendix I include over 820 plant and animal species, including all seven marine turtle species that are threatened with extinction and are or may be affected by trade (CITES, 2000). International trade in these species is subject to particularly strict regulation in order to avoid further endangering their survival. International commercial trade in Appendix I species of CITES and its products are prohibited. Non-commercial trade may be authorized in exceptional circumstances, such as for specimens acquired before the Convention entered into force, for personal or household effects, or for specimens bred in captivity, according to definitions adopted by the Conference of the Parties. Schedule I items of CITES shall possess export documents to the standard format recognized for international trade with non-CITES Parties. Irrespective of the prohibition of international trade on a commercial scale, marine turtles continue to be taken incidentally or opportunistically for domestic use and turtle products are traded illegally within the region and exported illegally (Elizabeth H. Fleming., 2001). Each shipment must be authorized and accompanied by an export permit from the country of origin, or re-export certificate from the country of re-export, as well as an import permit issued by the importing country.

To protect the turtles and their population, India is implementing many initiatives including banning of fishing turtle breeding season around nesting sites; practice of using Turtle Excluding Device (TEDs) in fishing nests to avoid by-catch of turtles, awareness campaign etc. Turtle nesting grounds have been classified as Ecologically Sensitive Area (ESA) under CRZ 2011and the activities in turtle nesting area have been prohibited and regulated.

Sustainability of turtle population has been pressurized by various anthropogenic activities in turtle nesting sites. Though, trafficking of sea turtle products is illegal, poverty of the third world countries or developing countries are driving the market (Didiher Chacon., 2002). In recent decades, there has been increased recognition that economic factors are behind many human activities that cause declines in habitats and species (Troeng and Drews, 2004).

Quantification of the economic consequences of marine turtle use and conservation contributes significantly to our understanding of use options and their ecological impacts, and hence further the process of defining adequate management policies. Expressing the economic value of various uses and benefits of turtle nesting grounds shall be a tool to raise awareness and convey its (relative) importance to general public and policy makers. These values shall help to make decisions about allocation of resources between competing uses (Farley, 2008). Accordingly, in this chapter, various goods and services of turtle nesting ground were identified and economic values of the above services have been fixed using benefit cost transfer method and other valuation methods. Application of economic value to turtle nesting grounds of India for policy decisions has been discussed.

Turtle nesting in beaches shall have the following main environmental variables for oviposition they include; fine sands, moderate slopes, good humidity and drainage, are. Turtles nesting grounds are the specific places where turtle population can be increased. To protect the turtle population, nesting grounds shall be essentially protected. Consumptive and non-consumptive economic valuation studies on turtle nesting sites shall provide an opportunity to create markets for conservation of turtle nesting grounds and to analyse the impacts of externalities. This shall lead to enhance our knowledge on total flow of benefits from turtle nesting ground. In view of the above, economic valuation of turtle nesting ground covers turtles and it's nesting beaches.

2. TURTLE NESTING GROUNDS IN INDIA - VALUATION

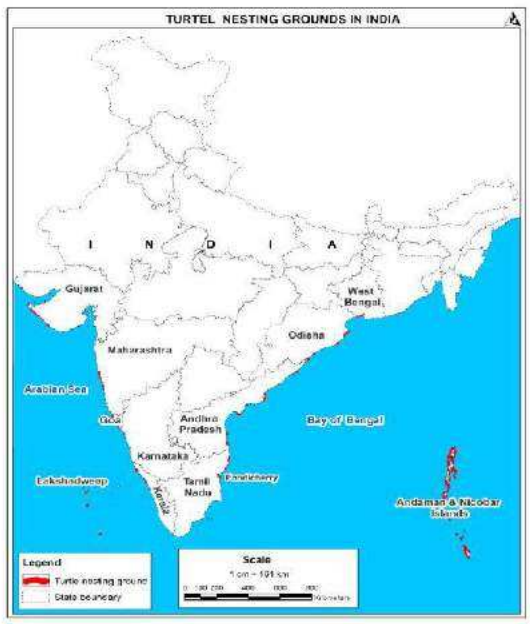


Fig 1

Turtle nesting grounds are distributed in 179 sites in the mainland coast and island coast of India. Total areas of nesting grounds distribution in India are 17872 ha. Andaman and Nicobar Islands have the highest number (102) of turtle nesting grounds covering 13344 ha area. In the mainland the coastal States viz., Maharashtra has 14 turtle nesting grounds followed by Gujarat and Andhra Pradesh. The above turtle nesting grounds are covering an area of 202 ha, 399 ha and 1375 ha respectively. Turtle nesting grounds of various coastal States and UTs of India has been given in chart Fig 1. It was estimated that up to one million sea turtles have nested in Odisha (873 ha) during a single year during the mid-1980's (Venkatraman and John Milton., 2003). Accordingly, one hectare of turtle nesting ground shall support 1145 turtles to lay eggs per year and the total nesting grounds of India support 211,67,615 number of turtles to lay eggs in 179 turtle nesting grounds. List of various turtle nesting grounds around India are given in table 2.1.

Table 2.1 Turtle nesting grounds in India				
S.No	**States**	**No of sites**	**Area (ha)**	**Common sp.**
1.	Gujarat	13	399.51	Olive ridley, Green turtle
2.	Maharashtra	14	202.20	Olive ridley
3.	Goa	6	25.54	Olive ridley
4.	Kerala	4	116.61	Olive ridley
5.	Lakshadweep	5	992.15	Olive ridley, Green turtle and Hawksbill
6.	Tamil Nadu	6	263.08	Olive ridley
7.	Pondicherry	2	15.79	Olive ridley
8.	Andhra Pradesh	12	1374.69	Olive ridley
9.	Odisha	11	872.93	Olive ridley
10.	West Bengal	4	265.48	Olive ridley
11.	Andaman & Nicobar	102	13344.06	Olive ridley, Green turtle, Hawksbill and Leatherback
	Total	**179**	**17,872.05**	**Olive ridley, Green turtle, Hawksbill and Leatherback**

Source: ESAs of India NCSCM report, 2015; http://morjimhermitagegoa.com/oliveridleyturtles.html

Table 2.2 Turtle Nesting Grounds – Indian Coastal Districts						
Sl. No	State / Union Territory	District	Patches in coastal areas	Turtle Nesting Grounds (ha)	Turtle density	Common sp.
1.	Gujarat	Devbhumi Dwarka	Lamba-Sethala Mata Mandir	32.55	31	Olive ridley, Green turtle
2.			Mithapur-Mojap	12.57	24	
3.			Sethala Mata Mandir-Harshad Mata Mandir	13.99	33	
4.			Okhamadhi-Kharakhetar	33.41	16	
5.			Mojap-Shivrajpur	13.14	32	
6.			Kharakhetar-Kuranga	25.57	20	
7.			Navadra-Lamba	40.44	34	
8.			Nearby Shivrajpur Beach	6.98	NA	
9.		Junagadh	Shil-Lohej	50.82	42	Olive ridley, Green turtle
10.			Mangrol-Mangrol Bara	20.57	37	
11.		Porbandar	Ratadi–Kantela	47.43	29	Olive ridley, Green turtle
12.			Kantela-Kuchhadi	50.55	37	
13.			Navibandar-Rativa	51.52	15	
Sub Total			13	399.51	350	Olive ridley, Green turtle
14.	Maharashtra	Ratnagiri	Kolthare	5.09	2	Olive ridley
15.			Sandkhol	4.32	NA	
16.			Velas	8.59	7	
17.			Guhagar	48.91	1	
18.			Kelashi	17.00	0.33	
19.			Dabhol	6.00	2	
20.			Bankot Fort	1.52	NA	
21.			Baag beach , Guhagar	6.64	NA	
22.		Raygad	Murud Janjira	2.79	NA	Olive ridley
23.			Diveagar	73.70	1	
24.			Harihareshwar	13.04	1	
25.			Maral	7.16	NA	
26.			Shining Sands Beach	0.08	NA	
27.			Vela's Beach	7.37	NA	
Sub Total			14	202.20	14	Olive ridley

28.	Goa	North Goa	Mandrem (Nearby Junos Vaddo village)	2.28	NA	Olive ridley
29.			Morjim (Morjim South)	3.11	NA	
30.			Mandrem	2.46	1	
31.			Morjim (Morjim North)	0.86	2	
32.		South Goa	Agonda	11.90	3	Olive ridley
33.			Galgibaga	4.92	3	
Sub Total			**6**	**25.54**	**9**	**Olive ridley**
34.	Kerala	Kozhikode	Kolavipalam	70.86	NA	Olive ridley
35.		Malappuram	Alungal	9.25	NA	
36.		Kasargod	Thaikkadappuram	20.32	NA	
37.		Kasargod	Hosdurg Beach	16.18	NA	
Sub Total			**4**	**116.61**	**NA**	**Olive ridley**
38.	Lakshadweep	Lakshadweep	Suheli Valliakara	58.33	NA	Green turtle
39.			Karingikuppu	24.20	NA	Green turtle
40.			Tinnakara	52.36	NA	Green turtle
41.			Minicoy group	513.16	NA	Olive ridley, Green turtle
42.			Agatti	344.10	NA	Olive ridley, Green turtle and Hawks bill
Sub Total			**5**	**992**	**NA**	**Green turtleOlive ridley &Hawks bill**
43.	Tamil Nadu	Chennai	Marina - Neelankarai (Urrur kuppam-kaveri Nagar)	67.69	8	Olive ridley
44.			Marina - Neelankarai (Marina - Srinivasa Puram)	86.06	8	
45.			Pattinapakkam	13.46	NA	
46.		Cuddalore	(Nearby Mandalpattu village)	3.95	NA	Olive ridley
47.		Kanchipuram	Alikuppam	44.17	NA	Olive ridley
48.		kanchipuram	Neelankarai - Uthandi	47.74	1	Olive ridley
Sub Total			**6**	**263.08**	**17**	**Olive ridley**
49.	Pondicherry	Pondicherry	Nearby village Nallavadu	3.46	NA	Olive ridley
50.			Nearby village Panithittu	12.34	NA	
Sub Total			**2**	**15.79**	**NA**	**Olive ridley**

51.	Andhra Pradesh	East godavari	Gautami Godavari - Nilarevu	360.94	68	Olive ridley
52.			Hope Island	61.72	7	
53.			Sacremento Island	74.36	373	
54.		Guntur	Krishna - Lankavanidibba	172.53	10	Olive ridley
55.		Krishna	Elichetladibba	346.96	31	Olive ridley
56.		Nellore	Pennaru - Mypadu	63.30	7	Olive ridley
57.			Sriharikota - Durgarajupatnam	88.67	8	Olive ridley
58.		Srikakulam	Bahuda - Kapaskuddi	85.24	40	Olive ridley
59.			Vamsadhara Bandaruvanipeta	37.39	55	
60.			Rajaram Puram Beach	10.03	NA	
61.			Kunduvanipeta - Nagavali	46.83	50	
62.		Vishakapatnam	Muthiyavanipalem	26.70	32	Olive ridley
Sub Total			**12**	**1374.69**	**681**	**Olive ridley**
63.	Odisha	Baleshwar	Digha (Nearby Digha village)	14.89	NA	Olive ridley
64.		Ganjam	Rushikulya	121.93	16667	Olive ridley
65.			Bahuda - Kapaskuddi	72.69	55	Olive ridley
66.		Jagathsinghpur	Akashdia Island (Devi)	314.45	10000	Olive ridley
67.		Kendrapara	Gahirmatha (Wheeler, Ekakula, Habalikati)	154.11	33333	Olive ridley
68.			Agarnasi	127.88	NA	
69.			Pentha	66.99	NA	
Sub Total			**11**	**873**	**60,055**	**Olive ridley**
70.	West Bengal	Purba Midnapore	Dadanpatra	51.10	NA	Olive ridley
71.			Junput	146.88	NA	Olive ridley
72.			Digha (Jagai Basan-Digha)	50.14	NA	Olive ridley
73.			Shankarpur	17.36	NA	Olive ridley
Sub Total			**4**	**265.48**	**NA**	**Olive ridley**
74.	Andaman & Nicobar	Andaman& Nicobar	Andaman & Nicobar	13344	8,026	Olive ridley, Green turtle, Hawksbill and Leatherback
Sub Total			**102**	**13344**	**8,026**	**Olive ridley, Green turtle, Hawksbill &Leatherback**
Total			**179**	**17872.05**	**69152**	**Olive ridley, Green turtle, Hawksbill &Leatherback**

3. VALUATION OF GOODS AND SERVICES OF TURTLE NESTING GROUNDS

Goods and services provided by marine turtles to the global community are economically valued by societies around the world (Daily et al. 2000). The economic values are significant for expressing utilitarian and non-consumptive values of sea turtles. In turtle nesting areas, regulation, cultural and supporting services generate gross revenue than consumptive use. It has been estimated that, the average gross revenue was 2.9 times higher at sites where marine turtles are a major tourist attraction than the average gross revenue of consumptive use sites (Troëng and Drews, 2004).

Under consumptive value of turtles, traditionally, all of their body parts have been used for specific purposes. Marine turtle meat and eggs have long provided a supplemental source of protein for coastal communities. Its eggs are often sought today for their supposed aphrodisiac qualities. Turtle products such as oil, calipee (cartilage), skin, viscera, shell, and curios are popular for coastal communities of the world (Elizabeth H. Fleming., 2001). According to Parsons (1972), antiquity information on the use of sea turtles products are available in Egyptians, Asians and Europe scripts. During colonial times, marine turtle utilization increased for use as food by ships' crews and for export to European countries. In 1950s and 1960s, international markets for shell from hawksbill turtles expanded, and markets developed and grew for green and olive ridley turtle shell and leather. The United States, Europe, and Japan were the major markets until domestic legislation and international regulations closed the legal trade to the United States and Europe (Elizabeth H. Fleming., 2001). It is clear that a culture and its folklore will not be lost by reducing or even stopping completely the use of sea turtles and their products. The sea turtle products have been continuously used locally and nationally. In the global market, turtle products have been illegally at least in lesser scale exported to demanding Nations. Japanese market is one of the most important consumers of sea turtle products, such as hawksbill shell (Didiher Chacón., 2002).

Turtle nesting site is a capital that provides opportunities including revenue generation using various incentives in cultural and supporting services. Turtle nesting beaches are protecting the coastal communities from storm surges, and cyclones. In addition, it acts as an aquifer and source of freshwater to the coastal communities of India. Developing countries have realized the benefit out of turtle nesting grounds service and conserve it by sustainable management. Countries promote tourism in the coastal areas to create awareness and educate the people about the goods and services of the turtle nesting areas. Costa Rica, Sri Lanka, Indonesia Malaysia and India are promoting sea turtle-based tourism. This tourism promotes insitu and exsitu conservations by marketing sea turtle nesting and hatcheries development. Sea turtle viewing has also been encouraged in India similar to Australia, South Africa, USA, and Israel. Furthermore, the turtle nesting grounds provide supporting services such as biodiversity maintenance, and are a source of scientific knowledge about land ocean interaction and migration. Turtle nesting sites goods and services have been influenced by many externalities. The goods and services of turtle nesting grounds, economic values, and application for policy values for sustainable management of turtle nesting grounds have been discussed in the following chapters.

4. META ANALYSIS (ACCOUNTING) TURTLE NESTING GROUNDS - GOODS AND SERVICES

A meta-analysis is defined as the study of studies (Melina Barrio, Maria L. Loureiro., 2010). Meta-analysis of turtle nesting ground was conducted by studying about 250 research studies. In the turtle nesting grounds, turtles are the key stone species and the nesting area has the qualities of general beaches hence it provides different services. Based on the research studies, the turtle fleshes have been consumed and its body parts have been used for ornamental purposes. The turtle nesting grounds have rare earth mineral deposits which has huge potential in the international market. The turtle nesting grounds also protect the coastal communities from hazards and thus increase real estate value. In addition, the turtle nesting grounds are a source of freshwater and minerals to the coastal communities. More than above, in Hindu mythology, turtles are second incarnation of lord Vishnu and have great spiritual and cultural value for coastal communities. In addition, the turtle nesting ground support the fishermen to land their boats, dry their

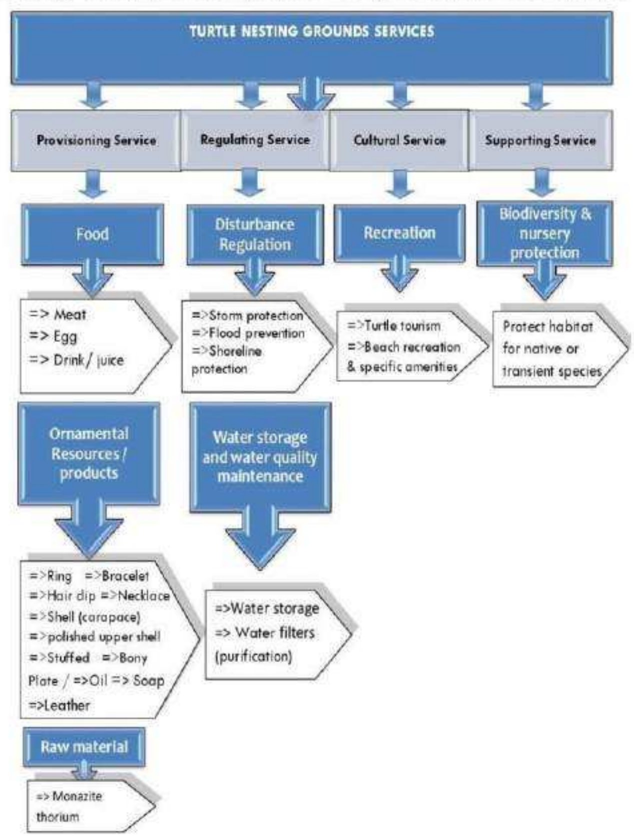


Fig2

harvests and it also acts as a market place. The turtle eggs and carcass are food for many vertebrates and invertebrates food web and are very significant to biodiversity and has significant scientific value. The scientific studies and research reports on turtle nesting grounds opened much information of the services provided by turtle nesting grounds. The services have been classified as (i) provisional service (ii) regulation services (iii) cultural services and (iv) supporting services following the Millennium Ecosystem Assessment (2005). The following chapters exhibits the various services and functions of turtle nesting grounds and the estimated value for various services. The list of studies which have been referred and used for valuation of various turtle nesting ground services and functions have been given in Annexure 1.

4.1. Provisioning services of turtle nesting grounds

Provisioning services of the turtle nesting grounds are the goods that can be used for human requirements. Turtle nesting grounds provide turtles, which are the key stone parameter of the Ecologically Sensitive Area (ESA). Marine turtles provides eggs, meat, shell, oil, leather or other products since at least 5000 BC (Frazier 2003). In India, it was observed that during the dynasty of Kanika, people were paying "Anda Kara" (revenue for the eggs) and were collecting boatload of eggs from the Gahirmatha rookery (Venkatraman, K. and M.C. John Milton., 2003).

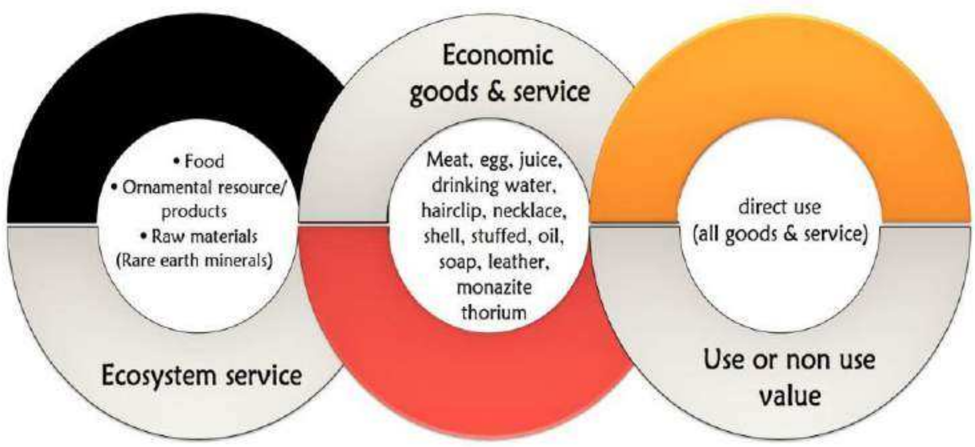


Fig 3

Hair clips, combs, rings, frames for glasses and other items, made from marine turtle are attractive ornamental uses of turtle in various countries. Central American countries have a use of olive ridley turtle oil for respiratory ailments for cold. The oil has strong smell and taste, and it also has a different colour and viscosity hence, it has been used for indigenous soap making (Didiher Chacon., 2002). During colonial times, marine turtle utilization increased for use as food by ships' crews and for export to European countries (Jackson 1997). Due to such trade, the green turtle was once called "...the world's most valuable reptile..." (Parsons 1962). In addition the turtle nesting beach sands provide varieties of economically important minerals. The raw materials in the form of sand has been mined for centuries for multiple uses, including extraction of minerals such silica and feldspar for glass and ceramic production, infill for development, amendments for agriculture, and base material for construction products (Edward B. Barbier etal., 2011).

4.1.1. Consumptive value

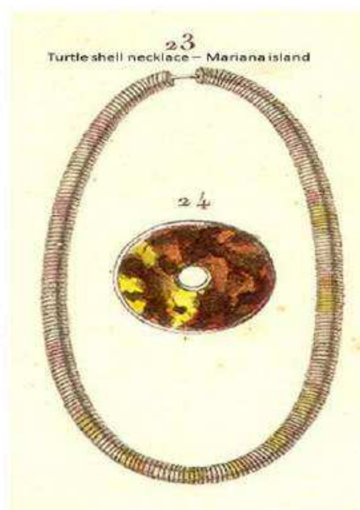
Turtle meat has been used for various purposes in India. Globally, turtle meat has been used for consumption purpose and has a consumptive value. Didiher Chacón (2002) has reported that there is no species wise variation in consumption due to taste. All turtles taste the same and the flavour depends on how it is cooked. In Caribean countries, wild turtle meat can fetch up to US$19.25-US$27.50/kilogram. A turtle farm sold turtle meat for US$13.20/kg. Cooked turtle meat dishes cost US$12-15 per dish (Elizabeth H. Fleming., 2001). However the turtle meat rate is very low in Livingston, Guatemela, where one kilogram of turtle meat sells for US$1.32 (Didiher Chacón., 2002). In India, out of the seven species of living sea turtles, juveniles and adults of three species are heavily exploited for commercial trade. The green sea turtle is taken for its much-favoured meat. Its belly, neck and tail bones are used for ingredient of turtle soup. In Andaman Islands all species except the leatherback was hunted for meat. The tribes of Andaman consume turtle meat minced with coconut. In Lakshadweep turtle meat is used as shark bait. Turtle fat was used to waterproof the boats in Lakshadweep islands. It was reported that during between 1963 and 1974, India exported 102,022 kg of sea turtle products valued at roughly $ 100,800. The products included sea turtle meat, oil and shell (Venkataraman, K. and M.C. John Milton., 2003).

Sánchez et al. (2002) reported that the average price per dozen eggs was $2.89 only. Generally, in Guatemala, raw turtle eggs are mixed with orange juice and consumed as a revitalizing drink in the morning. Normally this drink is sold for US$2-$3 per glass by street vendors along the sidewalks (Didiher Chacón., 2002). Eggs are thought to have aphrodisiac properties; they are mixed with wine, brandy, and beer to make "punch," which is sometimes called "front end lifter"

(Haynes-Sutton et al., 1995). The lower part of the body (plastron), which is salted and smoked over the hearth is consumed in soup approximately two or three months later; i.e., during the months when there are no fish (Didiher Chacon., 2002).

4.1.2. Non consumptive value

Hawksbill shell products, sold for very good price say a ring costs US$17.50, and bracelet cost US$25. Hawksbill scutes (bony plate made as handicrafts) to Belize City was sold for US$ 25.00 per pound (Didiher Chacón., 2002). The turtle parts are combined with other metals to make jewels. The costs of these ornamental goods in Caribean countries is valued for US$18.00 (Didiher Chacón., 2002). In Honduras, necklace made of hawksbill and black coral, priced at US$ 18.60 (Didiher Chacón., 2002). A hair clip that is possibly equal to the one found with a value of US$50 (Didiher Chacón., 2002). Accordingly, value of turtle shell covering a size of 10 cm² curved to develop a US$ 20 (Avg.). The sizes coming to the breeding for nesting ground is 182 Kgs (Avg) for Leatherback turtle which have a curved carapace length CCL 140-200 cm (170 cm) curved carapace width CCW of 106 cm Avg.). In Anguo wholesale market, around 9 kg of Hawksbill shell was observed in eight stalls. The price was significantly lower than that in Qingping. The average price was USD46 per kg, and the price range was USD37–59 per kg. (Timothy lam 2012, In India, due to thickness and colour of hawksbill sea turtle, it is used for jewellery, ornaments, or as delicate inlays and veneer on furniture. Most of the tortoise shell trade is believed to be from the hawksbill sea turtle (Venkataraman, K. and M.C. John Milton., 2003).



Stuffed turtles are marketed from US$ 32.50 to $62.50 Avg. at various sales points from fishermen to shop owners in Central America (Didiher Chacón., 2002). It has been reported that eight carapaces that were marketed after polish were priced from US$165 to US$220 each (Elizabeth H. Fleming., 2001). Ottenwalder (1996) reported that large sized stuffed hawksbill turtles were sold for US$550. The Central American countries use olive ridley turtle oil for respiratory ailments and colds. The oil has strong smell and taste, and it also has a different colour and viscosity. In Dangriga, Belize, a vendor was selling sea turtle oil cream for skin protection and nourishment and the cream cost US$ 2.50 each / 100 grams (Didiher Chacón., 2002). A single turtle can provide the right quantity of oil (i.e. between 10 and 20 liters of oil) for coating an entire pirogue (Tripathy and Choudhury 2007). Most turtle oil creams made in the 1930s contained less than than 10 per cent of the oil (0.5 g) with many creams being less than 5 per cent (deNavarre & Ruszkowski, 1933, p. 17). Soaps have also been made from oils sea turtles, and the soap was priced from $1.20/unit (200 gms) in Guatemala (Didiher Chacón., 2002). In addition turtle leather has been used for various purposes. It has been reported that poachers sell turtle leather for $15 US/turtle (Héctor Trinidad and James Wilson., 2000).

4.1.3. Rare earth minerals

In addition, minerals including silica of beach sands of turtle nesting grounds have significant value. Some minerals are important for National economy, strategic significance and military security. They are non-renewable and are more difficult to find, inventory and develop. Indian resources constitute about 35% of world resources of ilmenite, 10% of rutile, 14% of zircon, and 71.4% of monazite. India meets about 10% of the world requirement of garnet (Rajamanickam et.al., 2004). The minerals do not exist in natural form but it exists as Monazite oar. The monazite with other heavy minerals in the beach sand deposits along the coastal tracts is the major resource for rare earths in India. Atomic Minerals Directorate for Exploration and Research (AMDER), a constituent unit under the DEA has estimated that the 11.93 million tonnes of monazite resources are present in the beach sand mineral placer deposits along the coastal tracts of India. It has been reported that the grade of monazite falls between 1% and 5%. In the coastal States, the monazite distribution in selected beaches of Odisha, Andhra Pradesh, Tamil Nadu, Kerala and West Bengal are 2.41, 3.72, 2.48 and 1.90 and 1.22 tonnes respectively (Lok Sabha unstarred question No.328; answered on 22/07/2015). The list of beaches has been identified by AMDER (http://www.unece.org/fileadmin/DAM/energy/se/pp/unfc/UNFC_ws_India_Oct2013/5b.2_Parihar.pdf visited on 11/11/2016). Out of 30 turtle nesting grounds in India, placer sand are deposited in 2 locations of Andhra Pradesh beaches viz., (1) Vamsadhara (R) – Bandaruvanipeta (2) Bahuda (R) – Kapaskuddi. The highest thorium reserves have been witnessed in Andhra Pradesh (3.74Million Tonnes) in the country. US Department of Energy, office of Science,

Monazite particle

prices and certificate price list indicates the value of Monazite sand silica mixture (1%Th) costs $680/50g (http://science.energy.gov/nbl/certified-reference-materials/prices-and-certificates/uranium-thorium-ores-price-list/ pages visited on 11/11/2016).

The demand for monazite sand in the United States was limited to the incandescent gas mantle and the pyrophorie-alloy industries, according to the United States Bureau of Mines. During the war, the price of monazite sand delivered to New York, exclusive of the duty of $80 a ton, varied from $25 to $40 per unit (1 per cent per short ton) of thorium or from $ 150 to $240 per ton. Immediately after the war the price was quoted (November, 1919) at $27 per unit, or about $162 per ton of the 6 percent (thorium) sand, plus duty. Before the end of 1925 the price had dropped to $ 120 per ton. After increasing slightly during the latter part of 1928 to $ 130 per ton, the price dropped in 1929 to $60 a ton, the lowest figure so far recorded (Ind. Eng. Chem., 1930, 22 (12), pp 1407–1407)

Thorium metal cost $5000 - $5300 per Kg ($150/oz). That's around $5 million per tonne and that pegs the value of this scam to $ 974.5 Billion to $1035 Billion. Current values are as high as $5,000/kg, because the demand for the refined metal is very low. Projections are that thorium prices will drop to as low as $10/kg. Once thorium reactors move into production, prices will rise as demand grows (http://defenceforumindia.com/).

4.2. Regulation services

Sea turtles can emerge onto the beaches to deposit several batches of eggs during the course of a nesting season (Miller, 1997). Sea turtle species reproductive success depends mainly on the availability of terrestrial habitat to lay eggs. Geomorphology of the coastal area, slope of the beach, wave action, storms and the grain size of the sand are the essential characteristics of selection of turtle nesting ground in reproduction (Bird, 1996). For centuries, due to their unique position between ocean and land, the turtle nesting beaches and dunes have provided humans with important services such as raw materials, coastal protection, erosion control, water catchment and purification, maintenance of wildlife, carbon sequestration, and tourism, recreation, education, and research (Edward B. Barbier etal., 2011). Coastal protection is arguably one of the most valuable services provided by sand shore ecosystems especially in the face of extreme storms, tsunamis, and sea level rise. Turtle nesting grounds are the beaches that provide disturbance regulation (protection) function, water quality maintenance function and climate regulation function (Baird and Dann, 2003; Lastra et al., 2010). The turtle nesting ground of the natural beaches protect the life and livelihood of coastal communities from storm and flood damage. The turtle nesting ground beaches protect coastal wetlands by buffering the shorelines. It buffers the coastal wetland from erosion; reduce floodwaters impacts during cyclone and storms impacts. Details of disturbance regulation (protection) function of turtle nesting grounds have been explained in chapter 4.2.1.

Aquifers in lowland and coastal plains are the most important available source of renewable freshwater. Turtle nesting ground are potential source of renewable of freshwater. The turtle nesting ground acts as a buffer to renew the freshwater in the coastal aquifer and limits seawater intrusion into the coastal plains. The turtle nesting grounds acts as a freshwater reservoir and supply water to local communities during drought season. Freshwater stored in coastal aquifers is particularly vulnerable to degradation due to its close proximity to seawater, and the significant water demand associated with coastal areas whereby groundwater is often the main source of drinking water (Giada Felisa etal., 2013). Saltwater intrusion into coastal aquifers is one of the most significant global challenges coastal water resource managers, industries, and agriculture face (Ferguson and Gleeson 2012). Saltwater intrusion shall contaminate the potential water reservoirs of municipal, industrial, and agricultural water resources supplies (Barlow and Reichard 2010). The water storing, replenishing and water quality maintenance function of the turtle nesting ground are given in para 4.2.2.

Fig 4

4.2.1. Disturbance regulation function

Turtle nesting grounds are located in high-energy coastlines where the regional coastal slope is low and vulnerable to sea level rise, and flood damage hence the location is very important in coastal protection function (Jeffrey Pompe and Jennifer Haluska., 2011). As waves reach the shoreline of the turtle nesting grounds, they are attenuated by the beach slope and also by the fore dune, a structure immediately behind the beach where sand accumulates in hills or ridges parallel to the shoreline. Beaches vary in their ability to attenuate waves depending on a continuum in their morphology (Edward B. Barbier etal., 2011). Wider beaches provide protection from flooding during storms and high tides to oceanfront property as well as to homes and lots farther removed from the beach. Additionally, wider beaches also enhance the value of recreational activities such as strolling on the beach, sunbathing, and picnicking. Therefore, the expectation is that a wider beach increases the market price of property, since property values capture the flood control and recreational gains associated with a wider beach

(Pompe, J., and J. Rinehart., 1999). Serious erosion of beaches endangers oceanfront property and, in extreme cases, leads to houses toppling into the ocean. Therefore, the expectation is that a wider beach increases the market price of property, since property values capture the flood control and recreational gains associated with a wider beach.

By protecting the impacts from erosion and storm, the property values near to the turtle nesting grounds and beaches have been increased. Landry et al. (2003) found that, for one meter increase of beach width, property values increased by $233 on Tybee Island in the U.S. state of Georgia. Using hedonic pricing method, Pompe and Rinehart (1995) found that an additional foot of beach for two coastal communities in South Carolina increases the value of developed and undeveloped oceanfront lots by $554 and $754, respectively (Pompe, J., and J. Rinehart. 1995). Costanza et al., (1989) used WTP method to estimate storm reduction function of wetlands for $452/acre/year (in 2009 dollars) which shall be equivalent to beach protection function. Other than the above estimate, hurricane protection function of coastal wetlands range between USD 250 to USD 51 000 ha1 yr1, with a mean of USD 8240 ha1 yr1 (median ¼ USD 3230 ha1 yr1) applicable for turtle nesting grounds. By applying damage avoided cost, Costanza etal (2008) has estimated storm protection services of Louisiana coast at (USD) 1700 ha-1 yr (Robert Costanza etal., 2008).

4.2.2. Water storage and water quality maintenance function

In the coastal aquifers including beaches, gentle to nearly flat ground water table and semi-confined conditions fresh water occurs in shallow depths in discontinuous patches with deeper zones generally saline. Maximum thickness of 600 m and yield 3 - 38 lps (litre per second) from the coastal aquifers in coastal areas of India have been reported by Central Ground Water Board, India (CGWB., 2014). However, considering replenishable and water storing capacity of turtle nesting based on the average annual rainfall of 1200 mm. yr/ ha. 12000 m3 of water / year can be sustainably used. Managed Aquifer Recharge (MAR) and water banking are of increasing importance to water resources management. MAR can be used to buffer against drought and changing or variable climate, as well as provide water to meet demand growth, by making use of excess surface water supplies and recycled waters (Sharon and Dillon. 2015). Contamination of freshwater bodies caused by saltwater intrusion (SI) is a global issue, affecting water quality, vegetation, and soil conditions along coastal lines. Deterioration of this freshwater resource threatens the sustainability of the water supply of coastal communities and their economic development.

A popular approach among practitioners to assess the benefits of groundwater protection is the avoidance-cost method (Abdalla 1994; Rinaudo et al. 2005). It consists of assessing the cost of actions undertaken by economic agents to cope with groundwater degradation, and pollution in particular. Typical avoidance costs are those related to the closure and displacement of contaminated drinking water wells (public or private), the installation of sophisticated water treatment units (municipal or domestic) or the purchase of bottled water when groundwater can no longer be used as a safe source of drinking water (Cecile Herivaux and Jean-Daniel Rinaudo., 2016). Other than avoidance cost method, CVM/WTP method has been applied by Belloumi and Matoussi (2002) to estimate the value for preserving groundwater quality from saline intrusion in the Tunisian coastal areas. Accordingly the ground water protection value in the coastal aquifer is 41€/hh/year (currency value of 2013). In New Zealand, economic value of groundwater for abstractive users in the Waimea Plains, Nelson, New Zealand have estimated the ground water value of the plain to be $ 250 million, and the Waimea Plains 7500 ha area., accordingly, 1 ha ground water economic value is $33333/ha, and the mean willingness to pay $1.2 million to maintain groundwater, to keep springs and river flowing and prevent salt water intrusion (White etal., 2001). Because of the importance of this water source, the Meijendel dune (Netherlands) covering an area of 2000 ha has been managed as a nature reserve that serves both drinking water and recreation needs. In 1999, the cost of management was $3.8 million/year, while the yearly income of the reserve was $99.2 million/year (Edward B. Barbier etal., 2011). The cost of management of the water source area can be applied apart from Replacement cost method for valuation of water resources in the beaches. Also the economic valuations of in-situ groundwater resource in the Waimea Plains, Nelson, New Zealand were estimated $ 1.2 million; Groundwater left in-situ would maintain spring flow, maintain groundwater quality and prevent saltwater intrusion into groundwater system. In Lebanon, a CVM method was applied to value the ground water resources for agriculture process and the farmer's willingness to pay estimated that the value is about $ 134.3 ha. /Yr. (Daniel EL CHAMI etal., 2008).

4.3. Cultural services

Turtles are playing an important cultural, traditional, social and economic role in India. Turtle nesting grounds are sandy beaches that are the place for recreation and relaxation. It is a popular place for peacefulness, nature appreciation and play games and sports. Along with the turtle tourism, beach recreation increases the economic value of turtle nesting ground beaches. Turtles have spiritual value in Hindu mythology. According to Hindu mythology, the Indian deity Vishnu was reincarnated as "Kachhapa" – a turtle, holding the burden of the world on its back (Liz McLellan etal., 2005). In Hinduism, Kurma (Sanskrit: कूर्म; Kurma, lit. turtle) is the second avatar of Vishnu. Three temples in India have special spiritual relationship with turtles and they are popular pilgrimage sites. The temples dedicated to Kurma are located in Kurmai in Chittoor district, Andhra Pradesh, Srikurmam in Srikakulam District, Andhra Pradesh and Gavirangapur in Chitradurg District of Karnataka. In addition the nesting areas offer recreation function (Klein et al., 2004; Noriega et al., 2012). Among the cultural services, turtle nesting grounds providing recreation function and spiritual function.

Kurma Avatar of Vishnu, below Mount Mandara, with Vasuki wrapped around it, churning the ocean of milk during Samudra Manthan. ca 1870.

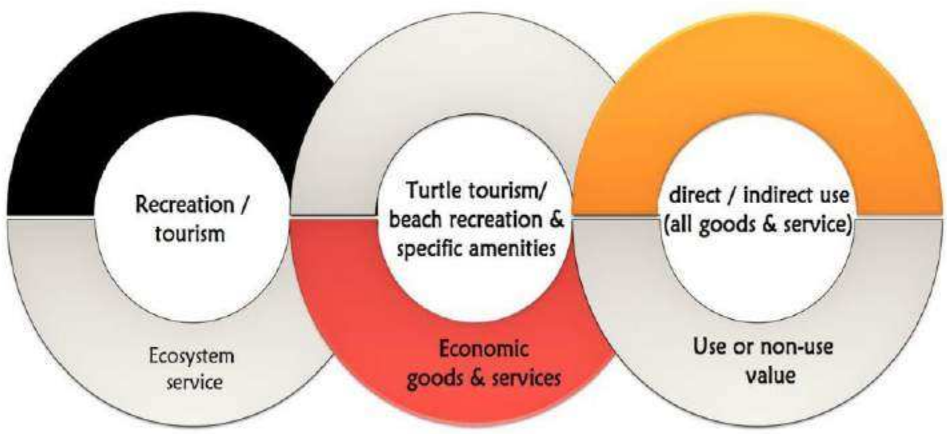


Fig 5

4.3.1. Recreation function

It has been estimated that, all over the world 175,000 tourists / year are participating marine turtle tours (Troëng and Drews, 2004). "It has been estimated that turtle-based tourism activities in Tortuguero, Costa Rica, generated more than US$6.5 million through tourism services, along the 22 miles (35 km) long "beach-resting turtles (tortugas) was estimated by travel cost method (benefit transfer) souvenir sales and national park fees, in 2002 alone (Liz McLellan etal., 2005)."

Expenditures for turtle tourism in international market are 26 times higher than whale watching (Hoyt 2001).

Time spent for travelling to and from the turtle nesting area (beaches) is time that could be spent in another productive activity, such as in another leisure activity or at work, and thus represents a real cost that must be accounted for in the price paid by the user in going to the turtle nesting ground. These time costs can be translated into money terms by multiplying time units by the shadow value of leisure time (SVLT), which is a measure of the opportunity cost of a unit of time spent in non-work activities. Using the estimated model, the mean (median) value of a beach day (turtle nesting ground) across the sample is \$28.27 with a standard error of \$5.55 /day (Daniel K. Lew, and Douglas M. Larson ., 2005).

School Girls watch sand artists, Puri, Orisssa, India

It has been estimated that, gross revenue for nine case studies, where non-consumptive use of marine turtles, such as tourism, is a major revenue generator range from US\$41,147 to US\$6,714,483 yr^{-1} per site with an average of US\$1,659,250 yr^{-1}. Gross revenue at four sites where marine turtles are one of many attractions varies between US\$3,387-US\$105,997 yr^{-1} with an average of US\$40,791 yr^{-1} (Troeng and Drews, 2004). Entire beach and adjacent land of Playa Grande Dominaican Republic, covering an area of 379 ha annual gross revenue from turtle tourism was estimated at US\$900,460 in 1993 (Gutic 1994). A capitalized commercial value of US\$ 8,002,820 and a capitalized recreational value of US\$ 31,269,296 were estimated for the turtles and estuary resources, which adds up to a present total annual capitalized economic value of US\$ 39,272,116 for these resources. Based on the estimated total economic value, a capitalized economic value of US\$ 13,090,705 was determined for the Tamarindo estuary and a capitalized value of US\$ 34,910 was set for every leatherback turtle which nested at Playa Grande during the 1992 - 1993 season. The capitalized economic value for the whole (local) leatherback turtle population was set at US\$ 26,181,411 for the same season

Marine turtles play an important role in Australian aboriginal culture. This contemporary design is drawn by Karen Puruntatameri

(Jorge Gutic M., 1994). It has been estimated that velas beach ratnagiri (Maharashtra) has 59 ha of turtle nesting grounds. Respondents were asked about their willingness to pay (WTP) for entry fee for recreational access along with turtle nesting habit were randomly offered 20 Rs per visit, Vela's to host almost 3,000 tourists during Turtle Festival seasons, annually 1016 Rs / ha /yr WTP (Pranab mukhopadhyay et.al 2016).

Puri, Odisha, India

Nice views are important to property owners, ocean front and ocean view property is highly valued than the inland properties (Edwards 1989). In an Island of South Carolina, during 1989, an average plot size of 25993 (SQFT) which are located in the oceanfront are varied between $22,718 and $36,373 based on development. The ocean view (not oceanfront) properties located in developed areas were between $12,780 and $33,016 however, the inland areas property values have been varied between $8,081 and $5,915 (1989$ estimate) respectively $143/foot, $343/foot, $103/foot and $549/foot altogether average of 285 $/ foot (Jwffrey, J. Pompe and James R. Rinehart., 1999). However, Hobbs (1980) used historical erosion rates to evaluate the impact of coastal erosion on shoreline property along the Chesapeake Bay. They found that the value of dwelling decreases by $0.24 for each square foot of shoreline lost and by $8.24 per foot of distance lost. Property owners value additional beach width differently, based on the state of development of the property, and the proximity to the beach. The value of an additional foot of beach is $58.19 for vacant lots and $80.98 for developed lots. Price differentials exist for property at different locations. An additional foot of beach adds $194.09 and $310.84, respectively, to developed and undeveloped oceanfront property (1989$ estimate) (Jwffrey, J. Pompe and James R. Rinehart., 1999).

Culture service by sand art and creativity

The turtle nesting ground such as beaches and dunes supply important recreational benefits such as boating, fishing, swimming, scuba diving, walking, beachcombing, collecting seashells, walking, jogging, viewing birds and sunbathing among the numerous recreational and scenic opportunities that are provided by beach and dune access (Edward B. Barbier etal., 2011). Values, estimated using both travel cost and contingent valuation methods, range from a low of just $0.07/trip in Delaware, Maryland, and New Jersey to highs of well over $70/activity day in California and Florida.

Linwood H. Pendleton (2006) estimated the economic use value of beach recreation at California beaches of 1,100 miles (1770 km) for $1.5 billion and $7.5 billion annually and the value of beach recreation in Florida (coastline were 700 miles (1,126 km) was between $886 million and just under $9 billion annually.

In addition, turtles provide spiritual service. Daily religious practices bring out the cultural value of a temple, church and mosque (Klamer, Arjo., 1996). Turtle temples support spiritual tourism of coastal regions. Since there is no macro analysis conducted for spiritual tourism of turtles, CVM will be applied to estimate the values of spiritual tourism benefits.

4.4. Supporting service

Supporting services of turtle nesting grounds does not necessarily have direct economic benefit but shall provide for ecosystem functioning, processes, maintenance of integrity, resilience, and so the delivery of other benefits, including soil, mineral, gas formation and water recycling. It is also an essential habitat for plants and invertebrates such as shellfish, birds, rodents, and ungulates (Carter 1990, Pye and Tsoar 1990; Baird and Dann, 2003; Lastra et al., (2010). The turtle species of Olive ridley nesting at Orissa is genetically distinct from other populations, and may even be the ancestral stock of other olive ridley turtle populations in other oceans (Liz McLellan etal., 2005). Hence, the olive ridley population reaching Orissa coast has special biological and scientific importance. Bjorndal and Jackson (2003) reported the presence of green turtles contributes to healthy seagrass beds. The sea turtles' grazing activity in sea grass beds control and stabilize the distribution and diversity of sea grasses and disburses nutrition to other organisms and ecosystems (Thayer & Engel 1982, Thayer et al. 1984). Nesting females are important food for many vertebrates living at the shore. The sea turtles have been attacked and eaten by jaguars, tigers and hyenas. The high protein eggs are an important food for several animals including jackals, mongooses, foxes, opossums, vultures, crows, lizards, snakes, crabs, and ants (Bjorndal & Jackson 2003). The turtle eggs directly influence the growth of vegetation's of beaches by supplying a concentrated source of high-quality nutrients in the sand (Bouchard, S.S. and Bjorndal, K.A. 2000). Limited nutrients in dune ecosystems, such as nitrogen, phosphorus and potassium, are partially provided to the ecosystem by un-hatched sea turtle eggs. These vital nutrients allow for the continued growth of vegetation and subsequent stabilization of beach dunes (Hannan, etal., 2007).

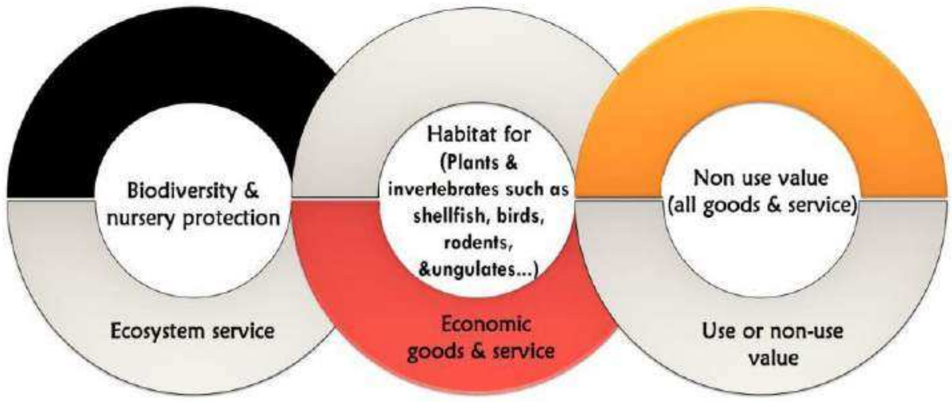


Fig 6

As the turtle nesting grounds have ecological and habitat significance by supporting the sustenance of large number of biological organisms, its existence and protection value is worth to incorporate under supportive service. It was estimated that an average weekly willingness to pay to protect sea turtles in Australia range between Aus $ 1.97 - 2.67 that the visitors to Mon Repos for the 2000 season would be prepared to pay at least Aus $250,000 per year to protect sea turtles in Australia for 9 mile (14 km) (Clevo Wilson and Clem Tisdell., 2002). Though, estimation of submissive values of turtle nesting services is difficult to measure in currency. Using CVM, a study in North Carolina in 1991 suggested that respondents would be willing to pay on average US$33.2 per year to conserve loggerhead turtles (Whitehead 1992). Turtles at Rekawa are under threat due to ongoing illegal activities. Mean willingness to pay (WTP) as an entrance fee to protect at Rekawa sanctuary and two national parks close to Rekawa sanctuary (i.e. Bundala and Yala as the offsite study sites) were (SLR) 106.05 and SLR 145.47. Annual revenue increases under these scenarios respectively to SLR 4.96 million and SLR 7.40 million, across the Rekawa beach of approximately 4 km. (Wasantha Rathnayake 2014). Respondents were asked about their willingness to pay (WTP) for beach nourishment that would result in a wider beach head for improved recreational access along with turtle nesting habit randomly offered $2.12 per visit, for a total of 1587 visitors surveyed and 3364$ willingness to pay on the time of survey for the total 5.1 mile (Manoj P. Shivlani., 2003). Using benefit transfer method, S'Abanell beach habitat valued 106 $/ha/yr (Lozoya et.al 2011).

5. Benefit Transfer and meta-analysis of turtle nesting grounds

The use and non-use values of the turtle nesting ground have been estimated at Rs. 45, 68,358/- yr. (Avg.). Out of which recreation function shares Rs. 29, 81,237/- yr. Disturbance regulation and water storage function of turtle nesting ground were estimated at Rs, 1, 17,866/ yr., and Rs. 12, 61,326/- yr., respectively. In addition, consumptive value of Rs. 2,07,929/ ha- was incorporated though there is no consumption value in India but, it has international market value. This value has been applied to the turtle nesting areas of India in relation to the composition of turtle species recorded by various scientific studies. The Total Economic Value from the turtle nesting ground is Rs.7997 Crore. Out of the total benefit from turtle nesting grounds, Andaman and Nicobar islands share Rs.5826 crore followed by Andhra Pradesh Rs. 601 crore.

Table 5.1 Turtle nesting grounds services values - ha / Yr.

Sl. No	Goods & services	Valuation Methods	Value estimation study	Year & Value	Value given US $	Value US $ 2011	Value in Rs. 2011	Avg. TEV value
I	Provisioning service							
I.1	Food (consumptive value)							
a.	Meat	Market Pricing	Didiher chacon	2002 23.3 $ /kg	23.3	28.3	1391	757/ kg
b.	Meat	Market Pricing	Elizabeth H. fleming	2001 13.20$/kg	13.2	16.2	800	
c.	Meat	Market Pricing	Didiher chacon	2002 1.32 $/ kg	1.32	1.60	79	
d.	Egg	Market Pricing	Sanchez Et. al	2002 2.89 $ / dozen	2.89	3.51	172	172/ dozen
I.2	Ornamental resource / Products (non - consumptive value)							
a.	Ring (scutes)	Market Pricing	Didiher chacon	2002 17.50 $/ ring	17.5	21.2	1044	9396/9 rings
b.	Bracelet (scutes)	Market Pricing	Didiher chacon	2002 25 $/ bracelet	25	30.3	1492	74600/ 50 bracelet
c.	Necklace (scutes)	Market Pricing	Didiher chacon	2002 18 $/ ornament	18	21.8	1074	6552 /6 necklace

d.	Necklace (scutes)	Market Pricing	Didiher chacon	2002 18.60 $/ ornament	18.60	22.60	1110	
e.	Hair clip (scutes)	Market Pricing	Didiher chacon	2002 50 $/ clip	50	60.7	2984	11936/ 4 hair clip
f.	Shell	Market Pricing	Didiher chacon	2002 20 $ / clip	20	24.3	1194	
g.	Shell	Market Pricing	Timothy lam et. al	2012 46 $/ shell	46	46	2260	
h.	Polished shell	Market Pricing	Elizabeth H. fleming	2001 24 $/ shell	24	29.6	1458	1601 / shell
i.	Bony Plate	Market Pricing	Didiher chacon	2002 25 $/ 1 kg of bony plate	25	30	1492	
J.	Stuffed	Market Pricing	Didiher chacon	2002 47.50 $/ stuffed	47.50	58	2835	19612 / turtle
k.	Stuffed	Market Pricing	Ottenwalder	1996 550 $/ stuffed	550	741	36390	
l.	Oil (fat)	Market Pricing	Didiher chacon	2002 2.50 US$ / 100 gm	2.79	137	27400	41800 / turtle
m.	soap(fat)	Market Pricing	Didiher chacon	2002 1.20 $ / 200 gm	1.46	72	14400	
n.	Leather	Market Pricing	Trinidad & James wilson	2000 15 $/turtle	15	18.9	930	930/ turtle
II	**Regulating service**							
II.1	**Disturbance regulation function**							
a.	Storm protection	CVM	Costanza et. al.	2009 452 $/ acre	452 $/ acre	467	56662	117866/ ha
b.				2008			86949	

		Damage avoided cost	Costanza et.al.	1700$/ha	1700$ / ha	1,770		
c.		Damage avoided cost	Costanza et. al.	2009 3230$/ha	3230 $/ ha	3,337	163927	
II.2	**Water storage and water quality maintenance function**							
a.	Water quality	CVM	Belloumi & Matoussi	2013 41€/ha	32 $/ ha	31	1523	
b.	Water quality	CVM	White et.al.	2001 160$/ha	160$/ ha	197	9677	
c.	Water quality	CVM	Daniel El Chami et.al.	2008 134.3 $/ha	134.3 $/ ha	139	6828	
d.	Water quality/ storage	Replacement cost	Edward B. Barbier et.al.	1999 3.8 million $/ 2000 ha	1900 $/ ha	2452	120452	1261326 / ha
e.	Water storage	CVM	White et.al.	2001 33333$/ha	33333 $/ ha	41116	2019782	
f.	Water storage	Market pricing	Edward B. Barbier et.al.	2000 95.4 million $/2000 ha	47700 $/ ha	60180	2956282	
III	**Cultural services**							
III. 1	**Recreation function**							
a.	Turtle tourism	CVM	Gutic	1993 900,460$ / 379 ha	2376 $/ ha	3398	166923	2981237 / ha
b.	Recreation	CVM	Gutic (general)	1993 31,269,296$/ 379 ha	82505 $ /ha	117978	5795551	

Table 5.2 Turtle nesting ground service value – minimum, maximum, average ha/yr./Rs.			
Service	Minimum value / ha	Maximum value / ha	Average value / ha
I. Provisioning service(Consumptive value)			
Consumption + commercial value (Ornamental resource (bracelet, ring, necklace, hairclip, oil, soap, shell, stuffed)	0 Kerala, West Bengal...	2227434 (Odisha)	207929
II. Regulating service(non- consumptive value)			
Disturbance regulation function	56662	163927	117866
Water storage and water quality maintenance function	1523	2956282	1261326
III. Cultural services			
Recreation function	166923	5795551	2981237
Total Economic value / ha			**4568358 (Forty Six Lakh)**

Table 5.3 Total economic value of turtle nesting grounds services Rs/ Yr.			
S.No	State / Union Territories	Turtle nesting distribution - ha	Total Value of Turtle nesting grounds
1.	Gujarat	399.51	1751596647
2.	Maharashtra	202.20	882154337
3.	Goa	25.54	111672599
4.	Kerala	116.61	508455859
5.	Lakshadweep	992.15	4326197888
6.	Tamil Nadu	263.08	1147441668
7.	Pondicherry	15.79	68870225
8.	Andhra Pradesh	1374.69	6013858517
9.	Odisha	872.93	5750762983
10.	West Bengal	265.48	1157610090
11.	Andaman & Nicobar	13344.06	58261309277
	Total	**17872.05**	**79979930092** (7997Crore)

6 Conclusion

Turtle nesting grounds are on land, and they are typically sandy beaches. Turtles have various ecological roles, sea turtles contribute to tourism activities, due to their charismatic nature, yielding great economic benefits. Quantification of the economic consequences of marine turtle use value and conservation could contribute significantly to our understanding of use options and their ecological impacts, and hence further the process of defining adequate management policies. Expressing the economic value of various uses and benefits of turtle nesting grounds shall be a tool to raise awareness and convey its (relative) importance to general public and policy makers.

The use and non-use values of the turtle nesting ground has been estimated at Rs. 45, 68,358 /- yr. /ha. Out of which consumptive value shares of Rs2, 07,929/ ha, has been incorporated in this study though there is no consumption in India but, it has international market value. The Total Economic Value of turtle nesting ground of India is Rs.7997 Crore. Out of the total benefit from turtle nesting grounds, Andaman and Nicobar islands share Rs.5826 crore followed by Andhra Pradesh Rs. 601 crore. The monetary values could be used in National, State and regional policies to integrate environment and economics.

7 References

Abdalla CW (1994) Groundwater values from avoidance cost studies: implications for policy and future research. Am J Agric Econ 76:1062–1067.doi:10.2307/1243392

Adamowicz, W, and T Graham-Tomasi.'Revealed Preference Tests of Nonmarket Goods Valuation Methods,' in Journal of Environmental Economics and Management. 20: 29-45 (1991)

Adamowicz, W, J Louviere, and M Williams. 'Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities,' in Journal of Environmental Economics and Management. 26: 271-292 (1994)

Allan, C. J. 1998. Conched out: A review of the trade in CITES-listed species in the United Kingdom overseas territories in the Caribbean. WWF-United Kingdom. Godalming, UK. 87

Allard, M.W., M.M. Miyamoto, K.A. Bjorndal, A.B. Bolten and B.W. Bowen. 1994. Support for natal homing in green turtles from mitochondrial DNA sequences. Copeia 1994(1):34-41

Andrews, H.V. & Shanker, K. 2002. A significant population of leatherback turtles in the Indian Ocean. Kachhapa, 6: 17.

Andrews, H.V., Krishnan, S. & Biswas, P. 2001. The status and distribution of marine turtles around the Andaman and Nicobar Archipelago.Govemment of India/UNDP sea turtle project report.Tamil Nadu, India, Madras Crocodile Bank Trust.animals: an analysis with surface-active peracarid crustaceans on the Atlantic coast of Spain. Mar. Biol. 157, 613–625.

Annie Kurian, 2013: Marine turtles along the Indian coast: Distribution Status, Threats and Management Implications, WWF- India pp 7-9.

Armstrong C. W., Folely N., Tinch R. and van den Hove S., 2010. Ecosystem Goods and Services of the Deep Sea, How and why we value ecosystem goods and services, Related Challenges and Recent Developments, Hotspot Ecosystem Research and Man's Impact On European seas (HERMIONE). at San Diego County Beaches. Coastal Management, 33:71–86.

Baird, B., Dann, P., 2003. The breeding biology of Hooded Plover Thinornis rubricollis, on Phillip Island, Victoria. Emu 103, 323–328.

Barlow, P. and Reichard, E. (2010).Saltwater intrusion in coastal regions of North America. Hydrogeology Journal, 18(1), 247-260.

Beach-goers willing to pay $166/trip or $1574 per visiting household per year (Landry and Liu 2009)

Beggs, J., J.A. Horrocks and B.H. Krueger. 2007. Increase in hawksbill sea turtle (Eretmochelys imbricata) nesting in Barbados, West Indies. Endangered Species Research 3:159-168.

Bell, Frederick, and Vernon Leeworthy.'Recreational Demand by Tourists for Saltwater Beach Days,'in Journal of Environmental Economics and Management. 18: 189-205 (1990)

Belloumi M, Matoussi MS (2002) Evaluation de la valeur de pre´servation de la qualite´ de la nappe d'Oued Kheirate. New Medit 1(4):39–45

Bernardo, J. & Plotkin, P. T. An evolutionary perspective on the Arribada phenomenon and reproductive behavioral polymorphism of Olive Ridley sea turtles (Lepidochelys olivacea). In Biology and Conservation of Ridley Sea Turtles (ed. Plotkin, P.) 363 pp. (The Johns Hopkins University Press, 2007).

Bhupathy, S. and Saravanan, S. 2002. Status of sea turtles along the Tamil Nadu coast. Kachhapa 7: 7–13.

Bin,O, T.W. Crawford, J.B. Kruse, and C.E. Landry, 2008. Viewscapes and Flood Hazard : Coastal Housing Market Response to Amenities and Risk. Land Economics 84; 434-448.

Bjorndal KA (1980) Nutrition and grazing behaviour of the green turtle (Chelonia mydas). Mar Biol 56:147–154

Bjorndal, K. A. & Bolten, A. . From Ghosts to Key Species: Restoring Sea Turtle Populations to Fulfill their Ecological Roles. Mar. Turt. Newsl.100, 16–21 (2003).

Bjorndal, K.A., Jackson, J.B.C. (2003) Role of sea turtles in marine ecosystems: reconstructing the past. In: Biology of Sea Turtles, Volume II. Lutz, P.L., Musick, J.A. ,Wyneken, J. (eds.) CRC Press, Boca Raton, pp. 259-273.

Bockstael, N, K McConnell, and I Strand. 'Recreation,' in Measuring the Demand for Environmental Quality, John Braden and Charles Kolstad, eds. Elsevier: Amsterdam, 1991.

Bouchard, S.S. and Bjorndal, K.A. 2000. Sea turtles as biological transporters of nutrients and energy from marine to terrestrial ecosystems. Ecology 81: 2305-2313.

Brill RW, Balazs GH, Holland KN, Chang RKC, Sullivan S, George JC (1995) Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (Chelonia mydas L.) within a foraging area in the Hawaiian islands. J Exp Mar Biol Ecol 185:203–218

Burt, Oscar and Durward Brewer. 'Estimation of Net Social Benefits From Outdoor Recreation,' in Econometrica. 39: 813-827 (1971)

Campbell, L. (2003) Contemporary culture, use, and conservation of sea turtles.Campbell, L. Contemporary culture, use, and conservation of sea turtles.In The Biology of sea turtles, Vol. 2 (eds. Lutz, P., Musick, J. & Wineken, J.) 455 pp. (CRC Press, 2003).

Campbell, L.M., 1998. Use them or lose them Conservation and the consumptive use of marine turtle eggs at Ostional, Costa Rica. Environmental Conservation 25(4): 305-319.

Carr, A. 1967.So Excellent a Fishe. Natural History Press, Garden City, New York.

Carr, A., Carr, M.H., Meylan, A.B. (1978) The ecology and migrations of sea turtles,The west Caribbean green turtle colony. Bulletin of the American Museum of Natural History 162: 1-46.

Carter, R. W. G. 1990. Coastal environments: an introduction to the physical, ecological and cultural systems of coastlines. Academic Press, London, UK.

Castro, C., Troëng, S., Monterrosa, L., Campbell, D., Chamorro, E., 2000. Valuation of the ecological damaged caused to the environment by green turtle (Chelonia mydas) hunting. Report to the public prosecutor of Limón, Costa Rica (in Spanish).13 pp.

Cattarinich, X., 2001. Pro-poor tourism initiatives in developing countries: Analysis of secondary case studies. PPT Working Paper No. 8. CRT, IIED and ODI, UK.91 pp.

Ce´cile He´rivaux and Jean-Daniel Rinaudo., 2016.Integrated Assessment of Economic Benefits of Groundwater Improvement with Contingent Valuation. A.J. Jakeman et al. (eds.), Integrated Groundwater Management. Chapter, 21, pages 519-548

Cesario.'Value of Time in Recreation Benefit Studies,' in Land Economics. 52: 32-41 (1976)

CGWB., 2014. Report on status of ground water quality in coastal aquifers of India. Ministry Of Water Resources Central Ground Water Board, Government of India. Central Ground Water Boar, Faridabad, Paes 1- 36.

Chadha, S and C.S. Kar., 1999.Bhitarkanika; Myth and Reality.Natraj publisher, Dehradun. pp 1-388.

Clevo Wilson and Clem Tisdell., 2002. Conservation and Economic Benefits of Wildlife-based Marine Tourism: Sea Turtles and Whales as Case Studies. Economics, ecology and the environment.Working Paper No. 64.The University of Queensland.Pages 1-19.

Clevo,W and Clem Tisdell., 2001. "Sea turtles as a non-consumptive tourism resource especially in Australia." Tourism Management 22.3 : 279-288

Conservación de las Tortugas Marinas en Centroamérica (RCA). San José, Costa Rica. XXX p.

Costanza, Matthew Wilson, Austin Troy, Alexey Voinov, Shuang Liu, and John D'Agostino., 2006.The Value of New Jersey's Ecosystem Services and Natural Capital.Gund Institute for Ecological Economics.Rubenstein School of Environment and Natural Resources.University of Vermont.pages 1- 177.

Costanza, R.; Farber, S. & Maxwell, J. (1989).The valuation and management of wetland ecosystems.Ecological Economics, 1, 335.

Daily, G.C., Söderqvist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P.R., Folke, C., Jansson, A., Jansson, B., Kautsky, N., Levin, S., Lubchenco, J., Mäler, K., Simpson, D., Starrett, D., Tilman, D., Walker B., 2000.The value of nature and the nature of value. Science 289: 395-396.

Daniel EL CHAMI, Maroun EL MOUJABBER, Alessandra SCARDIGNO., 2008. The Contingent Valuation Method for the economic assessment of Groundwater: A Lebanese case study. NEW MEDIT N. 3/2008, pages 19-24.

Daniel K. Lew and Douglas M. Larson., 2005. Valuing Recreation and Amenities

Daniel K. Lew, and Douglas M. Larson ., 2005. Valuing Recreation and Amenities at San Diego County Beaches. Coastal Management, 33:71–86.

Demetropoulos, A. Impact of tourism development on marine turtle nesting: strategies and actions to minimise impact. (2000).

Didiher Chacón., 2002. Assessment about the trade of the Sea Turtles and their products in the Central America Isthmus. Red Regional para la

Drews C., Fonseca A., 2009, Aumento del nivel del mar por cambio climático en Playa Grande, Parque Nacional Las Baulas, Costa Rica. Simulación de inundación basada en un modelo de elevación digital de alta resolución e implicaciones para el manejo del parque. Informe técnico, WWF / Stereocarto, San José, Costa Rica, 20 pp.

Eckert, K. L., J. A. Overing, and B. B. Lettsome. 1992. WIDECAST sea turtle recovery and action plan for the British Virgin Islands. CEP Technical Report No. 15.UNEP Caribbean Environment Programme, Kingston, Jamaica.116 pp.

Eckert, K.L. 1987. Environmental unpredictability and leatherback sea turtle (Dermochelys coriacea) nest loss. Herpetologica 43(3):315-323.

Ecosystem goods and services of Barnegat Bay beach, New Jercy, USA was estimated using benefit cost transfer method was 42,149 $/ac/yr. (NJEP., 2007).

Edward B. Barbier, Sally D. Hacker, Chris Kennedy, Evamaria W. Koch, Adrian C. Stier, And Brian R. Silliman., 2011. The value of estuarine and coastal ecosystem services. Ecological Monographs, 81(2), 2011, pp. 169–193.

Edwards, S. F. 1989. On estimating household demand for outdoor recreation from property values: An exploration. North-eastern Journal of Agricultural and Resource Economics 18:229–240.

Edwards, S. F. and F. J. Gable (1991)."Estimating the Value of Beach Recreation from Property Values: An Exploration with Comparisons to Nourishment Costs," Ocean & Shoreline Management 37-55.

Eliot, I. G., and D. J. Clarke, Semi-diurnal variation in beach face aggradation and degradation, Mar. Geol., 79, 1-22, 1988

Elizabeth H. Fleming., 2001. Swimming Against the Tide : Recent Surveys of Exploitation, Trade, And Management of Marine Turtles In the Northern

Caribbean. Published by TRAFFIC North America, Washington, D.C., USA, pages 1-185.

Englin, Jeffrey and Robert Mendelsohn. 'A Hedonic Travel Cost Analysis for Valuation of Multipla Components of Site Quality,' in Journal of Environmental Economics and Management. 21: 275-290 (1991)

Ernst, C.H.; Lovich, J.E. (2009). Turtles of the United States and Canada.JHU Press.ISBN 9780801891212.

Ernst, C. H., and J. E. Lovich. 2009. Chrysemys picta (Schneider, 1783): P ainted turtle. InTurtles of the United States and Canada. Johns Hopkins U niversity Press, Baltimore, MD, USA.

Fergus, Charles (2007). Turtles: Wild Guide. Wild guide. Mechanicsburg, PA: Stackpole books. p. viii. ISBN 9780811734202.

Ferguson, G. and Gleeson, T. (2012). Vulnerability of coastal aquifers to groundwater use and climate change. Nature Climate Change, 2(5), 342-345.

Fish, M. R. et al. Predicting the Impact of Sea-Level Rise on Caribbean Sea Turtle Nesting Habitat. Conserv.Biol. 19, 482–491 (2005).

Fish, M. R., et al., 2008. "Construction setback regulations and sea-level rise: mitigating sea turtle nesting beach loss." Ocean & Coastal Management 51 (4), 330-341.

Fish, M.R., I.M. Côté, J.A. Gill, A.P. Jones, S. Renshoff and A.R. Watkinson. 2005. Predicting the impact of sea-level rise on Caribbean sea turtle nesting habitat. Conservation Biology 19(2):482-491.

Fowler, L. 1979.Hatching success and the nest predation in the green sea turtle, Chelonia mydas, at Tortuguero, Costa Rica. Ecology 60(5): 946-955.

Frazer, N.B. (1992) Sea turtle conservation and halfway technology.Conservation Biology 6, 179.

Frazier, J. (2003) Prehistoric and ancient historic interactions between humans and marine turtles. In: Biology of SeaTurtles, Volume II. Lutz, P.L., Musick, J.A., Wyneken, J. (eds.) CRC Press, Boca Raton, pp. 1-38. References Male market, Maldives.Money Talks: Economic Aspects of Marine Turtle Use and Conservation

Frazier, J., Salas, S., Didi, N.T. (2000) Status of sea turtles in the Maldives.Maldives Marine Research Bulletin 4: 5-42.

Freeman, A. M. III (2003) The Measurement of Environmental and Resource Values. Resources for the Future, Washington D.C.

Fugazzatto, P. and C. Behera, 1999. Dead Turtles: Good for the Global economyA Joint Report by Sea Turtle Restoration Project and Project Swaraja. pp. 1-7.

Gerald J. Kauffman and Catherine Cruz-Ortíz., 2012.Economic Value of the Barnegat Bay Watershed. Institute for Public Administration School of Public Policy & Administration, College of Arts & Sciences, University of Delaware. Pages 1-66

Giada Felisa, Valentina Ciriello and Vittorio Di Federico., 2013. Saltwater Intrusion in Coastal Aquifers: A Primary Case Study along the Adriatic Coast Investigated within a Probabilistic Framework, Water 2013, 5, 1830-1847.

Giri, V. & Chaturvedi, N. 2003.Status of marine turtles in Maharashtra, India. Kachhapa, 8: 11–15. Parsons, G.R. and M. Powell, 2001.Measuring the Cost of Beach Retreat. Coastal Management 29; 91 - 103.

Godfrey, M. H. & Godley, B. J. Seeing past the red: flawed IUCN global listings for sea turtles. Endanger. Species Res. 6, 155–159 (2008).

Gourou.Mounton Paris La Haye.

Grinsted A., Moore J.C., Jevrejeva S., 2009, Reconstructing sea level from paleo and projected temperatures 200 to 2100AD. Climate, Dynamics.http://dx.doi. org/10.1007/s00382-008-0507-2. 461- 472.

Groombridge, B. and R. Luxmoore. 1989. The green turtle and hawksbill (Reptilia: Cheloniidae): World status, exploitation and trade. CITES Secretariat, Lausanne, Switzerland.601 pp.

Gutic, J., 1994. Sea turtle eco-tourism brings economic benefit to community. Marine Turtle Newsletter 64: 10-12

Hamann, M., Limpus, C. & Owens, D. (2003) Reproductive cycles of males and females. In The Biology of sea turtles, Vol. 2 (eds. Lutz, P., Musick, J. & Wineken, J.) 455 pp. (CRC Press, 2003).

Hanley, Nick and Clive Spash. Cost Benefit Analysis and the Environment. Edward Elgar Publishing, England: 1995.

Hannan, L.B., Roth, J.D., Ehrhart, L.M., and Weishampel, J.F. 2007.Dune vegetation fertilization by nesting sea turtles. Ecology 88(4): 1053-1058..29

Harry V. Andrews, B.C. Choudhury, B. Pandav, B. Tripathy and Kartik Shanker 2011. Sea Turtles of India: A Comprehensive Field Guide to Research, Monitoring and Conservation A manual by Dakshin foundation, Bangalore & Madras Crocodile Bank Trust. pp. 2-5.

Hawkes, L. A., Broderick, A. C., Godfrey, M. H. & Godley, B. J. Climate change and marine turtles. Endanger. Species Res. 7, 137–154 (2009).

Haynes-Sutton, A., R. Kerr, and A. Donaldson. 1995. Draft sea turtle recovery action plan for Jamaica. Prepared by the Wider Caribbean Sea Turtle Recovery Team and Conservation Network (WIDECAST) for the UNEP Caribbean Environment Programme. Kingston, Jamaica. Unpublished report.147 pp.

Hays, G C., and J.R. Speakman. 1993. Nest placement by loggerhead turtles, Caretta caretta. Animal Behavior 45:47-53.

Hays, G.C., A. Mackay, C.R. Adams, J.A. Mortimer, J.R. Speakman and M. Boerema. 1995. Nest site selection by sea turtles. J. Marine Biology Association, UK 75:667-674.

Héctor Trinidad and James Wilson., 2000. The Bio-economics of Sea Turtle Use in Mexico: History of Exploitation and Conservation Policies for the Olive Ridley (Lepidochelys olivacea). International Institute of Fisheries Economics and Trade (IIFET) → 10th IIFET Conference, July 10-14, 2000, Corvallis, Oregon, U.S.A.

Heppell, S., Snover, M. & Crowder, L. Sea turtle population ecology.In The Biology of sea turtles, Vol. 2 (eds. Lutz, P., Musick, J. & Wineken, J.) 455 pp. (CRC Press, 2003).

Hope, R.A., 2002. Wildlife harvesting, conservation and poverty: the economics of olive ridley egg exploitation. Environmental Conservation 29(3): 375-384.

Horrocks, J.A. and N.M. Scott. 1991. Nest site location and nest success in the hawksbill turtle Eretmochelys imbricata in Barbados, West Indies. Marine Ecology Progress Series 69:1-8.

http://morjimhermitagegoa.com/oliveridleyturtles.html

Hussein, A.R., 2000. Minister's preface. Maldives Marine Research Bulletin 4:1-2

Ibarra Martin, M. E., G. Espinosa Lopez, F. Moncada G., J. Angulo Valdes, G.

In The Biology of sea turtles, Vol. 2 (eds. Lutz, P., Musick, J. & Wineken, J.) 455 pp. (CRC Press, 2003).

IUCN (2003) 2003 IUCN Red List of Threatened Species. http://www.redlist.org

Iverson, J.B.; Kimerling, A. Jon; Kiester, A. Ross (1999). "List of All Families".Terra Cognita Laboratory, Geosciences Department of Oregon State University.Retrieved October 2012.

Jackson, J.B.C. (1997) Reefs since Columbus.Coral Reefs 16 Suppl.: S23-S32

James W. Nybakken, 2001. Marine Biology: An Ecological Approach, Benjamin Cummings, fifth edition, pp 276-279.

Janzen, F.J. 1994. Vegetational cover predicts the sex ratio of hatchling turtles in natural nests. Ecology 75:1593-1599.

Janzen, F.J. and C.L. Morjan. 2001. Repeatability of microenvironment-specific nesting behaviour in a turtle with environmental sex determination. Animal Behaviour 62:73-82.

Jeffrey Pompe and Jennifer Haluska., 2011.Estimating the Vulnerability of U.S. Coastal Areas to Hurricane Damage.Hurricane Research - Climate, Dynamics, and Societal Impacts. Chapter 21, pages 407 - 418

Jorge Gutic M., 1994. Sea Turtle Eco-Tourism Brings Economic Benefit to Community. Marine Turtle Newsletter 64:10-12.

Jwffrey, J. Pompe and James R. Rinehart., 1999. Establishing Fees for Beach Protection : Paying for a Public Good. Coastal Management, 27:57–67.

Kamel, S.J. and N. Mrosovsky. 2005. Repeatability of nesting preferences in the hawksbill sea turtle, Eretmochelys imbricata, and their fitness consequences. Animal Behaviour 70:819-828.

Kamel, S.J. and N. Mrosovsky. 2006. Deforestation: risk of sex ratio distortion in hawksbill sea turtles. Ecological Applications 16(3):923-931.

Kartik Shanker, 2004. Marine turtle status and conservation in the Indian Ocean.Expert consultation on interactions between sea turtles and fisheries within an ecosystem context. FAO Fisheries Report No. 738, Supplement FIRM/R738 Suppl. ISSN 0429-9337, Rome.

Kemp, A., Horton, B., Culver, S., Corbett, D., van de Plassche, O., Gehrels, W., Douglas, B., and Pamell, A. (2009). Time and magnitude of recent accelerated sea-level rise (North Carolina, United States). Geology, 37(11), 1035-1038

Kikukawa, A., N. Kamezaki and H. Ota. 1999. Factors affecting nesting beach selection by loggerhead turtles (Caretta caretta): a multiple regression approach. J. Zoo. Lond. 249:447-454.

Klamer, Arjo. 1996. "The value of culture : on the relationship between economics and arts." Pp. 243. Amsterdam: Amsterdam University Press.

Klein, Y.L., Osleeb, J.P., Viola, M.R., 2004. Tourism-generated earnings in the coastal zone: a regional analysis. J. Coast. Res. 20, 1080–1088.

Krinsky, I., and A. L. Robb. 1986. On approximating the statistical properties of elasticities. Review of Economics and Statistics 68:715–719.

Lagueux, C.J., 1991. Economic analysis of sea turtle eggs in a coastal community on the Pacific coast of Honduras. In: Neotropical Wildlife Use and Conservation.

Landry, C. E., A. G. Keeler, and W. Kriesel. 2003. An economic evaluation of beach erosion management alternatives. Marine Resource Economics 18:105–127.

Landry, C. E., and H. Liu. 2009. A semi-parametric estimator for revealed and stated preference application to recreational beach visitation. Journal of Environmental Economics and Management 57:205–218.

Lastra, M., Schlacher, T.A., Olabarria, C., 2010. Niche segregation in sandy beach

Levin, S. 1999. Fragile Dominion: Complexity and the Commons. Peruses Books, Reading, MA.

Lewsey, C., G. Cid and E. Kruse. 2004. Assessing climate change impacts on coastal infrastructure in the eastern Caribbean. Marine Policy 28:393-409.

Li, L., D. A. Barry, J.Y. Parlange and C. B. Pattiaratchi., 1997. Beach water table fluctuations due to wave run-up: Capillarity effects. Water Resources Research, vol. 33, NO. 5, PAGES 935-945.

Limpus, C. J. Impacts of climate change on marine turtles: A case study. In Migratory species and Climate Change: Impacts of a Changing Environment on wild animals. (UNEP/CMS, 2006).

Linwood H. Pendleton., 2005. The Economic and Market Value of Coasts and Estuaries: What's At Stake .Produced by Restore America's Estuaries. 2020 N. 14th St., Ste. 210 Arlington, VA 22201 .Pages 1- 182.

Linwood H. Pendleton., 2006. Market Value of Coasts and Estuaries: What's At Stake Produced by Restore America's Estuaries, Restore America's Estuaries, Arlington, VA 22201, pages 1-182.

Liz McLellan, Amanda Nickson, and Jo Benn., 2005.Marine turtle conservation in the Asia Pacific region.Published by WWF.pages 1-28).

Lori Ann Brinn., 2008. Assessment of differences in physical properties of sand associated with beach nourishment and effects on loggerhead sea turtle (Caretta caretta) nesting in northwest Florida. A thesis presented to the graduate school of the University of Florida in partial fulfilment of the requirements for the degree of Master of Science, University of Florida. Pages 1- 70.

Lotze, H. et al. Depletion, degradation, and recovery potential of estuaries and coastal seas.Science.312, 1806–1809 (2006).

Lutz, P., Musick, J. & Wynecken, J.The biology of sea turtles.455 pp. (CRC Press, 2003).

Major, Christopher and Kenneth M. Lusht, PhD, MAI.(2004). "Beach Proximity and the Distribution of Property Values in Shore Communities."The Appraisal Journal.

Makowski C, Seminoff JA, Salmon M (2006) Home range and habitat use of juvenile Atlantic green turtles (Chelonia mydas) on shallow reef habitat in Palm Beach, Florida, USA. Mar Biol 148:1167–1179

Manoj P. Shivlani., 2003. Visitor preferences for public beach amenities and beach restoration in South Florida. Coastal Management, 31:367–385

Márquez-M, R. & Márquez-M., R. Sea turtles population dynamics, with special emphasis on sources of mortality and relative importance of fisheries impacts – Atlantic Ocean. FAO Fish. Rep. No. 738 1–26 (Food and Agricultural Organization of the United Nations (FAO), 2004).

Mast, R. B., Hutchinson, B. J. & Pilcher, N. J. The Burning Issues for global sea turtle conservation, 2006: The hazards and urgent priorities in sea turtle conservation. Indian Ocean Turt.Newsl.3, 29–31 (2006).

McConnell, Kenneth. 'Congestion and Willingness to Pay: A Study of Beach Use,' in Land Economics. 53:185-195 (1977)

McConnell, Kenneth. 'The Economics of Outdoor Recreation,' in Handbook of Natural Resource and Energy Economics, vol. II. Kneese and Sweeney, eds. Elsevier Publishers: Amsterdam, 1985.

Mendonca MT (1983) Movements and feeding ecology of immature green turtles (Chelonia mydas) in a Florida lagoon. Copeia 4:1013–1023

Millennium Ecosystem Assessment 2005 [1], Chapter 2 "Analytical Approaches for Assessing Ecosystem Condition and Human Well-being" in Millennium Ecosystem Assessment, 2005: Current State and Trends", Volume 1, Island Press.

Miller, J. (1997) Reproduction in sea turtles. in The Biology of sea turtles (eds. Lutz, P. & Musick, J.) (CRC Press, 1997).

Miller, J. D. 1985. Embryology of marine turtles, p.269-328. In: C. Gans, F. Billett and P. F. A. Maderson (Editors), Biology of the Reptilia Vol. 14A. NY: Wiley-Interscience.

Miller, J. Reproduction in sea turtles.in The Biology of sea turtles (eds. Lutz, P. & Musick, J.) (CRC Press, 1997).

Milton, S. & Lutz, P.(2003) Physiological and Genetic Responses to Environmental Stress. in Biol. sea turtles, Vol. 2 (eds. Lutz, P., Musick, J. & Wynecken, J.) 510 pp. (CRC Press, 2003).

Moll, D. 1985.The marine turtles of Belize.Oryx. 19(3):155-257.

Moran, Kathleen L., and Karen A. Bjorndal., 2005. "Simulated green turtle grazing affects structure and productivity of seagrass pastures." Marine Ecology Progress Series 305: 235-247.

Mortimer, J.A. (1982) Factors influencing beach selection by nesting sea turtles, p.45- 51. In: K.A. Bjorndal (Editor), Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Mortimer, J.A., 1984. Marine turtles in the Republic of Seychelles: Status and management. Publication of the IUCN Conservation Library: Gland, Switzerland. 80 pp. + 4 pl.

Mrosovsky, N. 1983.Conserving Sea Turtles. British Herpetological Society, London.

Mrosovsky, N. and Yntema, C.L., 1980. Temperature dependence of sexual differentiation in sea turtles: implications for conservation practices. Biological Conservation, 18, 271- 280

Naess, A., 1989. Ecology, Community, and Lifestyle: Outline of an Ecosophy. Cambridge University Press, Cambridge.

National Marine Fisheries Services/US Fish And Wildlife Service (1996) Recovery plan for US Pacific populations of the olive ridley turtle (Lepidochelys olivacea). Silver Spring, MD, USA: NMFS & USFWS: vi 43 10 pp.

NEP, 2006. National Environmental Policy, MoEF, Government of India.Pagiola, S. & Bishop, J., 2004. Assessing the Economic Value of Ecosystem Conservation.October, 58(101), p.48.

New Jersey Department of Environmental Protection, 2007.Valuing New Jersey's Natural Capital: An Assessment of the Economic Value of the State's Natural Resources.

Nielsen, P., 1999. "Groundwater Dynamics and Salinity in Coastal Barriers". Journal of Coastal Research, 15(3), 732-740.

Nodarse Andreu, G. Hernandez Agilera, and J. Pacheco Roberto. 2000. University project on the study of Cuban sea turtles. Pages 16-18 in F. A. Abreu-Grobois, R. Briseño-Dueñas, R. Márquez, and L. Sarti, compilers. Proceedings of the Eighteenth International Symposium on Sea Turtle Biology and Conservation, 3-7 March

1998, Mazatlán, Sinaloa, Mexico. NOAA Technical Memorandum NMFS-SEFSC-436.293 pp.

Noriega, R., Schlacher, T.A., Smeuninx, B., 2012. Reductions in ghost crab populations reflect urbanization of beaches and dunes. J. Coast. Res. 28, 123–131.

Ogden JC, Robinson L, Whitlock K, Daganhardt H, Cebula R (1983) Diel foraging patterns in juvenile green turtles (Chelonia mydas L.) in St. Croix United States Virgin Islands. J Exp Mar Biol 66:199–205

Ottenwalder, J. A. 1996. Conservation and management of sea turtles in the Dominican Republic.Unpublished report.Conservation and Management of Coastal Biodiversity Project, United Nations Development Program. Santo Domingo, Dominican Republic. 21 pp.

Owens, D.W., M.A. Grassman and J.R. Hendrickson. 1982. The imprinting hypothesis and sea turtle reproduction. Herpetologica 38(1):124-135.

Pagiola, S. & Bishop, J., 2004.Assessing the Economic Value of Ecosystem Conservation.October, 58(101), p.48.

Pandav, B. and B.C. Choudhury. 1999. An Update on the Mortality of the Olive Ridley Sea Turtles in Orissa, India. Marine Turtle Newsletter.83 : 10-12.

Parsons, J. 1972. The Hawksbill Turtle and the Tortoise Shell Trade. Pp. 45-60. In: Etudes de geographie tropicale offertes a Pierre

Parsons, J.J. (1962) The Green Turtle and Man. University of Florida Press, Gainesville

Perman, R, Ma, Y., McGilvray, J., Common, M., 2003.Natural Resource and Environmental Economics.3rd Edition. Pearson Education Ltd, London.

Pishum Migraine and Douglas Hykle, 2014. Socio-economic and cultural implications of marine turtle use and conservation: a review of the literature from the IOSEA region, Version 2: 3, pp 20-22

Planning Commission., 2011. Report of working group on mineral exploration and development (other than coal & lignite) for the xii five year plan (2012-17). Pages 1-180

Plotkin, P. T. Adult migrations and habitat use.in The Biology of Sea Turtles, Vol. 2 (eds. Lutz, P., Musick, J. & J, W.) 455 pp. (CRC Press, 2003

Polasky, S., Costello, C. and Solow, A. (2005).The Economics of Biodiversity.Chapter 29 in K.-G.Maler and J.R. Vincent (Eds.).Handbook of Environmental Economics Volume 3. Elsevier Science.

Poloczanska, E. S., Limpus, C. J. & Hays, G. C. Vulnerability of marine turtles to climate change.Adv. Mar. Biol. 56, 151–211 (2009).

Pompe, J., and J. Rinehart. 1995. Beach quality and the enhancement of recreational property value. Journal of Leisure Research 27:143–154.

Pompe, J., and J. Rinehart.Establishing Fees for Beach Protection: Paying for a Public Good. Coastal Management, 27:57–67.

Pompe, J.J and J.R. Rinehart, 1995.Beach quality and the enhancement of recreational property values. Journal of Leisure Research 27 (1995) 143-154.

Pye, K., and H. Tsoar. 1990. Aeolian sand and sand dunes. Unwin Hyman, London, UK.

Rajamanickam, GV., N Chandrasekar, N Angusamy, VJ Loveson., 2004. Status of beach placer mineral exploration in India.Sustainable Development of Coastal Placer Minerals (Eds) Loveson, VJ and Misra, pages 9-21.

Ramachandran.S. 2001 Coastal Environment And Management. Institute for Ocean Management, Anna University, Chapter I, 1-5.

Raubenheimer, B and R. T. Guza ., 1999. Tidal water table fluctuations in a sandy ocean beach. Water Resources Research, Vol. 35, No. 8, Pages 2313-2320,

Re. V and G. M. Zuppi., 2011. Influence of precipitation and deep saline groundwater on the hydrological systems of Mediterranean coastal plains: a general overview, Hydrological Sciences Journal, 56:6, 966-980

Reiser, A. 2012. The Case of the Green Turtle: An Uncensored History of a Conservation Icon. Baltimore: Johns Hopkins University Press.

Richardson, J.I., R. Bell and T.H. Richardson. 1999. Population ecology and demographic implications drawn from an 11-year study of nesting hawksbill turtles, Eretmochelys imbricata, at Jumby Bay, Long Island, Antigua, West Indies. Chelonian Conservation and Biology 3(2):244-250.

Rinaudo J-D, Amal C, Blanchin R, Elsass P, Mailhac A, Loubier S (2005) Assessing the cost of groundwater pollution: the case of diffuse agricultural pollution in the Upper Rhine valley aquifer. Water Sci Technol 52(9):153–162

Robert Costanza, Octavio Pe´rez-Maqueo, M. Luisa Martinez, Paul Sutton, Sharolyn J. Anderson and Kenneth Mulder., 2008.The Value of Coastal Wetlands for Hurricane Protection. Ambio Vol. 37, No. 4, pages 241-248.

Robinson, J.G., Redford, K.H. (eds.) University of Chicago Press, Chicago, pp. 136-144.

ROC., 2002. Transfer of the population in Cuban waters from Appendix I to Appendix II, pursuant to Resolution Conf. 9.24. Proposal presented to the 12th Conference of the Parties, Santiago (Chile), 3 - 15 November 2002. Convention on International Trade in Endangered Species of Wild Fauna and Flora.26 pp.

Rolston III, H., 1994. Conserving Natural Value. Columbia University Press, New York.

Russell, Scott., 1998. Tiempon I Manmofo'na.Ancient Chamorro Culture and History of the Northern Mariana Islands.Micronesian Archaeological Survey no. 32. Saipan, CNMI: Commonwealth of the Northern Mariana Islands: Commonwealth of the Northern Mariana Islands. Division of Historic Preservation, 1998.

Sánchez, R., Jolón, M., Villagrán, J. y L. Boix. 2002. Estrategia nacional de manejo y conservación de tortugas marinas. Consejo Nacional de Áreas Protegidas (CONAP). Ciudad de Guatemala, Guatemala. 113 p.

Sarah S. Bouchard and Karen A. Bjorndal., 2000. Sea turtles as biological transporters of nutrients and energy from marine to terrestrial ecosystems. Ecology, 81 (8), 2305-2313.

Sebestian Troëng, and Carlos Drews (2004) Money Talks: Economic Aspects of Marine Turtle Use and Conservation, WWF-International, Gland, Switzerland pp 5 – 17.

Segar, D. (2012) Introduction to Ocean Sciences. 563 pp. (Open source textbook).

Seminoff (2002) 2002 IUCN Red list global status assessment, green turtle Chelonia mydas.IUCN Marine Turtle Specialist Group Review.93 pp.

Seminoff, J. A. & Shanker, K. Marine turtles and IUCN Red Listing: a review of the process, the pitfalls, and novel assessment approaches. J. Exp. Mar. Bio. Ecol. 356, 52–68 (2008).

Senko, J., Schneller, A. J., Solis, J., Ollervides, F. & Nichols, W. J. (2011) People helping turtles, turtles helping people: Understanding resident attitudes towards sea turtle conservation and opportunities for enhanced community participation in Bahia Magdalena, Mexico. Ocean Coast.Manag.54, 148–157 (2011).

Sharon B. Megdal and Peter Dillon., 2015.Policy and Economics of Managed Aquifer Recharge and Water Banking. Water 2015, 7, 592-598.

Shaw, Douglass. 'Recreational Demand by Tourists for Saltwater Beach Days: Comment,' in Journal of Environmental Economics and Management. 20: 284-289 (1991)

Simpson, R. D. (1998) Economic analysis and ecosystems: some concepts and issues. Ecological Applications 8(2): 342-349.

Smith, Kerry and Yoshiaki Kaoru.'Signals or Noise Explaining the Variation in Recreation Benefit Estimates,' in American Journal of Agricultural Economics. May 1990: 419-433.

Smith, M.D., D. McNamara, J.M. Slott, and A.B. Murray, 2009.Beach Nourishment as a Dynamic Capital Accumulation Problem.Journal of Environmental Economics and Management.

Spencer, R.-J. 2002. Experimentally testing nest site selection: fitness trade-offs and predation risk in turtles. Ecology 83:2136–2144.

Spencer, R.J. and M.B. Thompson. 2003. The significance of predation in nest site selection of turtles: an experimental consideration of macro- and microhabitat preferences. OIKOS 102:592-600.

Spotila, J.R., Reina, R.D., Steyermark, A.C., Plotkin, P.T. & Paladino, F.V. (2000) Pacific leatherback turtles face extinction. Nature 405: 529-530.

Sternberg, J. (1981) The worldwide distribution of sea turtle nesting beaches. (Center for Environmental Education, 1981).

STEVE A. JOHNSONI, KAREN A. BJORNDAL, and ALAN B. BOLTEN ET AL (1996) A Survey of Organized Turtle Watch Participants on Sea Turtle Nesting Beaches in Florida, Organized Sea Turtle Watch Survey, Florida 32611 USA pp 60- 64.

Sunderraj, W.S.F., Joshua, J. & Serebiah, S. 2001. Sea turtles along the Gujarat coast. Kachhapa, 5: 12–14.

Thayer, G.W., Bjomdal, K.A., Ogden, J.C., Williams, S.L., Zieman, J.C., 1984. Role of larger herbivores in seagrass communities. Estuaries 7: 351-376.

The value of beach-going, recreational fishing, and wildlife viewing are each greater than $4 billion annually, and the value may be nearly $50 billion annually for wildlife viewing and nearly $30 billion for beach-going and recreational fishing.

Tisdell, C., Wilson, C. (2001) Tourism and the conservation of sea turtles: an Australian case study. In: C. Tisdell (Editor), Tourism Economics, the Environment and Development: Analysis and Policy. Edward Elgar, Cheltenham, UK, pp. 356-368.

Tisdell, C., Wilson, C. (2002) Ecotourism for the survival of sea turtles and other wildlife. Biodiversity & Conservation 11: 1521-1538.

Tripathy, B., Choudhury, B.C. & Shanker, K. 2002.A survey of marine turtles and their habitats of the Lakshadweep Archipelago, India.A Government of India/UNDP sea turtle project report.Dehradun, Wildlife Institute of India.

Troëng, S. and Drews C., 2004. Money talks: Economic aspects of marine turtle use and conservation, WWF-International, Gland, Switzerland www.panda.org, Pages 1-64).

Troëng, S., Evans, D., 2004. Internesting and Post Nesting Migration Behavior of Green Turtles Chelonia mydas Elucidated through Satellite Telemetry. Marine Biology.

UNEP, 2006.Ecosystems and Biodiversity in Deep Waters and High Seas.UNEP Regional Seas Reports and Studies No. 178.UNEP/ IUCN, Switzerland 2006. ISBN: 92-807-2734-6 Job Number: DEP/0850/CA

Vargas-Mena, E., 2000. Significados culturales de la tortuga verde (Chelonia mydas) en el Caribe costarricense. In: Actitudes hacia la fauna en Latinoamérica. Nassar-Montoya, F., Crane, R. (eds.) Humane Society Press, Washington D.C. pp. 161-176.

Vieitas CF, Lopez GG, Marcovaldi MA (1999) Local community involvement in conservation—the use of mini-guides in a programme for sea turtles in Brazil. Oryx 33:127–131

Wallace, B. P. et al. Impacts of fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. Ecosphere 4, 1–49 (2013).

White PA, Sharp BM, Kerr GN (2001) Economic valuation of the Waimea Plains groundwater system. J Hydrol (New Zealand) 40:59–76

Whitehead, J. C., 1992. Ex ante willingness to pay with supply and demand uncertainty: implications for valuing a sea turtle protection programme. Applied Economics 24: 981-988.

Whiting SD, Miller JD (1998) Short term foraging ranges of adult green turtles (Chelonia mydas). J Herpetol 32:330–337

Whitmore, C.P. and P.H. Dutton. 1985. Infertility, embryonic mortality and nest site selection in leatherback and green turtles in Surinam. Biol. Conserv. 34:251-272.

Wilson EO (ed) (1988) Biodiversity. National Academy Press, Washington D.C., USA.

Wilson, C. & Tisdell, C. Conservation and Economic Benefits of Wildlife-Based Marine Tourism: Sea Turtles and Whales as Case Studies. Hum. Dimens.Wildl.8, 49–58 (2003).

Wood, D.W and K.A. Bjorndal. 2000. Relation of temperature, moisture, salinity, and slope to nest site selection in loggerhead sea turtles. Copeia 2000(1):119-128.

Woody, J.B., 1986. On the dollar value of the Oaxacan ridley fishery. Marine Turtle Newsletter 36: 6-7.

Zydelis, R., Wallace, B., Gilman, E. & Werner, T. Conservation of marine megafauna through minimization of fisheries bycatch.Conserv.Biol. 23, 608–616 (2008).

Annexure – 1

Turtle nesting grounds – Services, Functions & Methods

Sl. No	Year	Value estimation study	Location	Ecosystem Service &Sub-Service			Methods
1	2002	Didiher chacon	Caribbean (Grand Cayman island)	Provisioning service	Food	Meat	Market Pricing
2	2001	Elizabeth H. fleming	British Virgin Islands			Meat	Market Pricing
3	2002	Didiher chacon	Guatemala (Livingston)			Meat	Market Pricing
4	2002	Sanchez et al	Guatemala			Egg	Market Pricing
5	2002	Didiher chacon	Guatemala			Drink/ juice	Market Pricing
6	2002	Didiher chacon	Belize (Dangriga)		Ornamental resource / Products	Ring (scutes)	Market Pricing
7	2002	Didiher chacon	Margarita Island, Venezuela			Bracelet (scutes)	Market Pricing
8	2002	Didiher chacon	Belize City			Bony Plate (scutes)	Market Pricing
9	2002	Didiher chacon	Caribbean			Ornament (scutes)	Market Pricing
10	2002	Didiher chacon	Honduras			Ornament (scutes)	Market Pricing
11	2002	Didiher chacon	Panama			Hair clip (scutes)	Market Pricing
12	2012	Timothy lam et. al	China (Anguo, Hebei)			Shell (carapace)	Market Pricing

13	2001	Elizabeth H. fleming	Central America			Polished shell (carapace)	Market Pricing
14	2002	Didiher chacon	Caribbean			Stuffed	Market Pricing
15	1996	Ottenwalder	Caribbean			Stuffed	Market Pricing
16	2002	Didiher chacon	Dangriga, Belize			Oil (fat)	Market Pricing
17	2002	Didiher chacon	Guatemala			soap(fat)	Market Pricing
18	2000	Trinidad & James wilson	Mexico			Leather	Market Pricing
19	2003	Landry et.al.	U.S. state of Georgia (Tybee Island)	**Regulating service**	**Disturbance Regulation**	Storm protection	Hedonic pricing
20	1995	Pompe & Rinehart	South Carolina			Storm protection	Hedonic pricing
21	2009	Costanza et. al.	Global			Storm protection	Contingent valuation
22	2009	Costanza et. al.	Global			Hurricane protection	Damage avoided cost
23	2008	Costanza et.al.	Louisiana coast			storm protection	Damage avoided cost
24	2013	Belloumi & Matoussi	Central Eastern Tunisia		**Water storage & water quality maintenance**	Water quality	Contingent valuation
25	2001	White et.al.	waimea plains nelson			Water quality	Contingent valuation
26	2008	Daniel El Chami et.al.	Lebanon			Water quality	Contingent valuation
27	1999	Edward B. Barbier et.al.	Netherlands (Meijendel dune)			Water quality	Replacement cost
28	2001	White et.al.	Waimea plains nelson			Water storage	Contingent valuation
29	2000	Edward B. Barbier et.al.	Netherlands (Meijendel dune)			Water storage	Market pricing

30	1993	Gutic	Costa Rica (Tamarindo)	Cultural	Recreation	Turtle tourism	Contingent valuation
31	1993	Gutic	Costa Rica (Tamarindo)			Recreation	Contingent valuation

Annexure – 2

Turtle nesting grounds Total Economic Value service & patch wise valuation

Sl. No	Patches in coastal areas	Turtle Nesting Grounds -ha.	Provisional Service	Regulating Service	Cultural Service	Total Economic Value
1	Lamba Sethala Mata Mandir	32.55	829660	44887147	97027262	142744069
2	Mithapur Mojap	12.57	657697	17332868	37466422	55456987
3	Sethala Mata Mandir Harshad	13.99	885678	19288065	41692739	61866482
4	Okhamadhi Kharakhetar	33.41	444046	46076819	99598837	146119702
5	Mojap Shivrajpur	13.14	859623	18124237	39177030	58160891
6	Kharakhetar Kuranga	25.57	563899	35260804	76219128	112043832
7	Navadra Lamba	40.44	923458	55772227	120556259	177251945
8	Shil Lohej	50.82	1135284	70089847	151504972	222730105
9	Mangrol Mangrol Bara	20.57	1011003	28370671	61325539	90707213
10	Maktupur Mangrol	6.98	0	9623578	20802156	30425734
11	Ratadi–Kantela	47.43	800999	65410729	141390674	207602402
12	Kantela Kuchhadi	50.55	1011003	69714095	150692754	221417852
13	Navibandar Ratiya	51.52	428413	71053352	153587667	225069432
	Gujarat	**399.51**	**9550763**	**551004442**	**1191041443**	**1751596647**
14.	Kolthare	5.09	64754	7024007	15182968	22271729
15.	Sandkhol	4.32	0	5955759	12873864	18829624

16.	Velas	8.59	226639	11853009	25621255	37700903
17.	Guhagar	48.91	45328	67454039	145807456	213306823
18.	Kelashi	17.00	10684	23443598	50675266	74129549
19.	Dabhol	6.00	64754	8268391	17872808	26205953
20.	Murud Janjira	2.79	0	3848443	8318726	12167169
21.	Diveagar	73.70	32376	101643769	219711371	321387517
22	Harihareshwar	13.04	32377	17984171	38874266	56890814
23	Maral	7.16	0	9871220	21337455	31208675
24		1.52	0	2096229	4531171	6627400
25		6.64	0	9156821	19793221	28950042
26		0.08	0	108018	233489	341507
27		7.37	0	10164730	21971901	32136631
	Maharashtra	**202.20**	**476912**	**278872205**	**602805220**	**882154337**
28	Mandrem (Nearby Junos Vaddo village)	2.28	0	3149344	6807567	9956912
29	Morjim (Morjim South)	3.11	0	4295191	9284409	13579601
30	Mandrem	2.46	48565	3392651	7333493	10774709
31	Morjim (Morjim North)	0.86	64754	1192420	2577514	3834688
32	Agonda	11.90	97131	16406975	35465027	51969133
33	Galgibaga	4.92	107815	6784495	14665244	21557554
	Goa	**25.54**	**318266**	**35221077**	**76133256**	**111672599**
34	Kolavipalam	70.86	0	97726504	211243879	308970383
35	Alungal	9.25	0	12756349	27573899	40330249
36	Thaikkadappu ram	20.32	0	28022601	60573158	88595759
37		16.18	0	22317770	48241697	70559468
	Kerala	**116.61**	**0**	**160823225**	**347632634**	**508455859**
38	Suheli Valliakara	58.33	0	80446890	173892573	254339463
39	Karingikuppu	24.20	0	33378239	72149811	105528050
40	Tinnakara	52.36	0	72220561	156110687	228331248
41	Minicoy group	513.16	0	707739684	1529837567	2237577252
42	Agatti	344.10	0	474579415	1025842459	1500421875

	Lakshadweep	**992.15**	**0**	**1368364791**	**2957833097**	**4326197888**
43	Marina - Neelankarai (Urrur kuppam- kaveri Nagar)	67.69	123153	93360970	201807419	295291541
44	Marina - Neelankarai (Marina - Srinivasa Puram)	86.06	156572	118695379	256569828	375421779
45	(Nearby Mandalpattu village)	3.95	0	5451590	11784061	17235651
46	Alikuppam	44.17	0	60916932	131676960	192593892
47	Neelankarai - Uthandi	47.74	19426	65844891	142329150	208193467
48	Marina - Neelankarai Kuppam)	13.46	0	18568341	40136997	58705337
	Tamil Nadu	**263.08**	**299151**	**362838102**	**784304415**	**1147441668**
49	Nearby village Nallavadu	12.34	0	17017092	36783844	53800936
50	Nearby village Panithittu	3.46	0	4766376	10302913	15069289
	Pondicherry	**15.79**	**0**	**21783467**	**47086758**	**68870225**
51	Gautami Godavari - Nilarevu	360.94	0	497805506	1076047565	1573853071
52	Hope Island	61.72	0	85126714	184008397	269135110
53	Sacrement Island	74.36	12076620	102559440	221690668	336326728
54	Krishna - Lankavanidib	172.53	337368	237957824	514365419	752660611
55	Elichetladibba	346.96	991704	478529034	1034379886	1513900625
56	Pennaru - Mypadu	63.30	215954	87308129	188723705	276247788
57	Sriharikota - Durgarajupat	88.67	259016	122299330	264360066	386918412
58	Bahuda - Kapaskuddi	85.24	1295079	117558446	254112255	372965781
59	Vamsadhara -	37.39	1780735	51564761	111461474	164806970

60		10.03	0	13838872	29913860	43752732
61	Kunduvanipeta - Nagavali	46.83	1618850	64588646	139613674	205821170
62	Muthiyavanipalem	26.70	1036064	36827589	79605864	117469517
	Andhra Pradesh	**1374.69**	**19611391**	**1895964292**	**4098282834**	**6013858517**
63	Digha (Nearby Digha village)	14.89	0	20532820	44383381	64916202
64	Rushikulya	121.93	539616774	168167102	363507030	1071290907
65	Bahuda - Kapaskuddi	72.69	1780734	100248611	216695621	318724966
66	Akashdia Island (Devi)	314.45	323769984	433680844	937436831	1694887658
67	Gahirmatha (Wheeler, Ekakula, Habalikati)	154.11	1079233345	212546963	459437751	1751218059
68	Agarnasi	127.88	0	176373960	381246828	557620788
69	Pentha	66.99	0	92391839	199712564	292104403
	Odisha	**872.93**	**1944400837**	**1203942140**	**2602420006**	**5750762983**
70	Dadanpatra	51.10	0	70476589	152340948	222817537
71	Junput	146.88	0	202572979	437878165	640451144
72	Digha (Jagai Basan-Digha)	50.14	0	69149960	149473328	218623288
73	Shankarpur	17.36	0	23949438	51768682	75718121
	West Bengal	**265.48**	**0**	**366148967**	**791461123**	**1157610090**
74	Andaman & Nicobar	13344.06	75480895	18404021489	39781806893	58261309277
	Andaman & Nicobar	**13344.06**	**75480895**	**18404021489**	**39781806893**	**58261309277**
	Total TNG value	**17872.05**	**2050138215**	**24648984198**	**53280807679**	**79979930092**

Annexure – 3

State wise Total economic value of turtle nesting grounds services					
Sl.No	**State / Union Territories**	**Provisioning Service value**	**Regulating Service value**	**Cultural Service value**	**Total economic value**
1.	Gujarat	9550763	551004442	1191041443	1751596647

2.	Maharashtra	476912	278872205	602805220	882154337
3.	Goa	318265	35221077	76133256	111672599
4.	Kerala	0	160823225	347632634	508455859
	Lakshadweep	0	1368364791	2957833097	4326197888
5.	Tamil Nadu	29915 0.8078	362838102	784304415	1147441668
6.	Pondicherry	0	21783467	47086758	68870225
7.	Andhra Pradesh	19611391	1895964292	4098282834	6013858517
8.	Odisha	1944400837	1203942140	2602420006	5750762983
9.	West Bengal	0	366148967	791461123	1157610090
10.	Andaman & Nicobar	75480895	18404021489	39781806893	58261309277
	Total	**2050138215**	**24648984198**	**53280807679**	**79979930092**

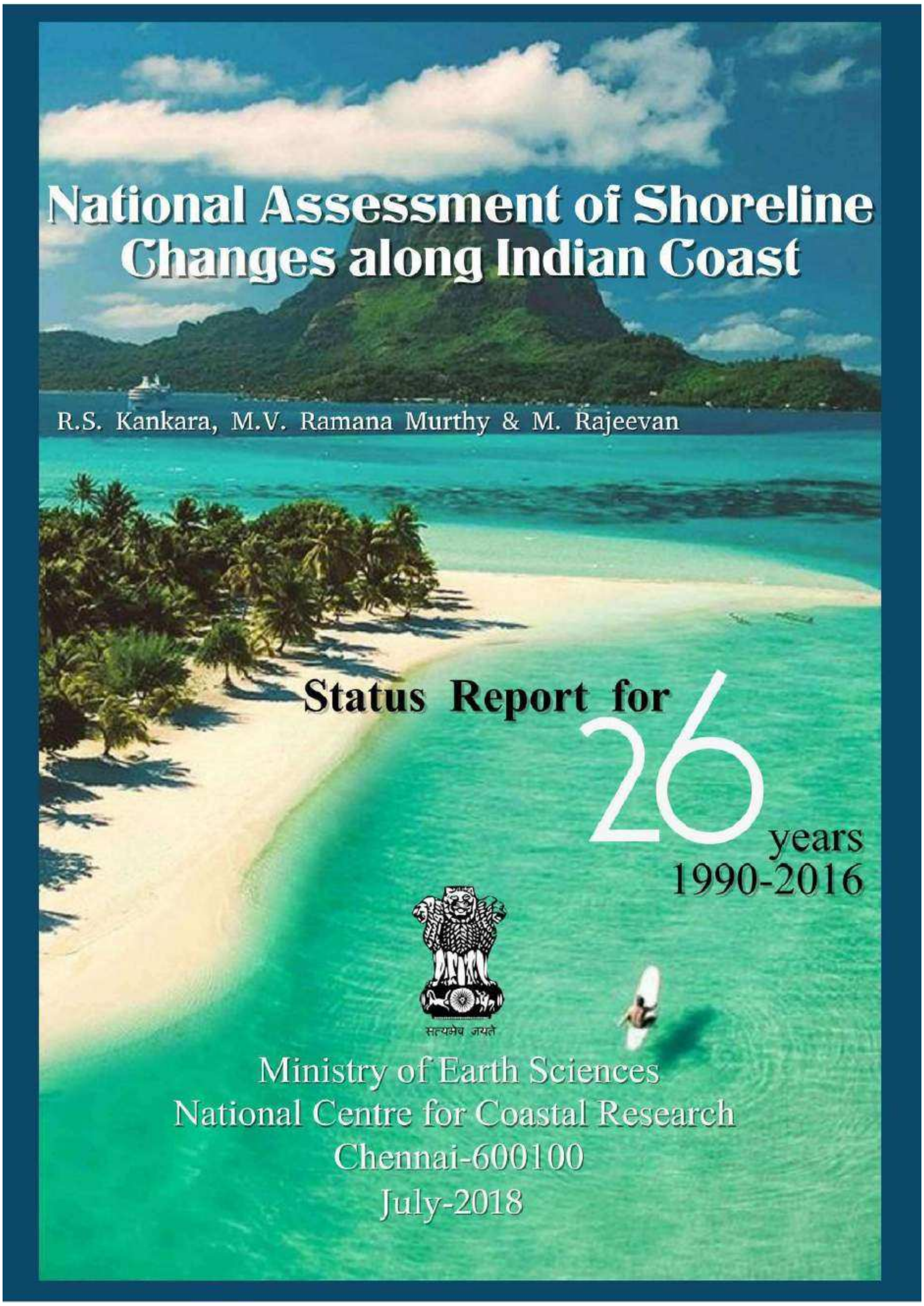
Annexure – 4

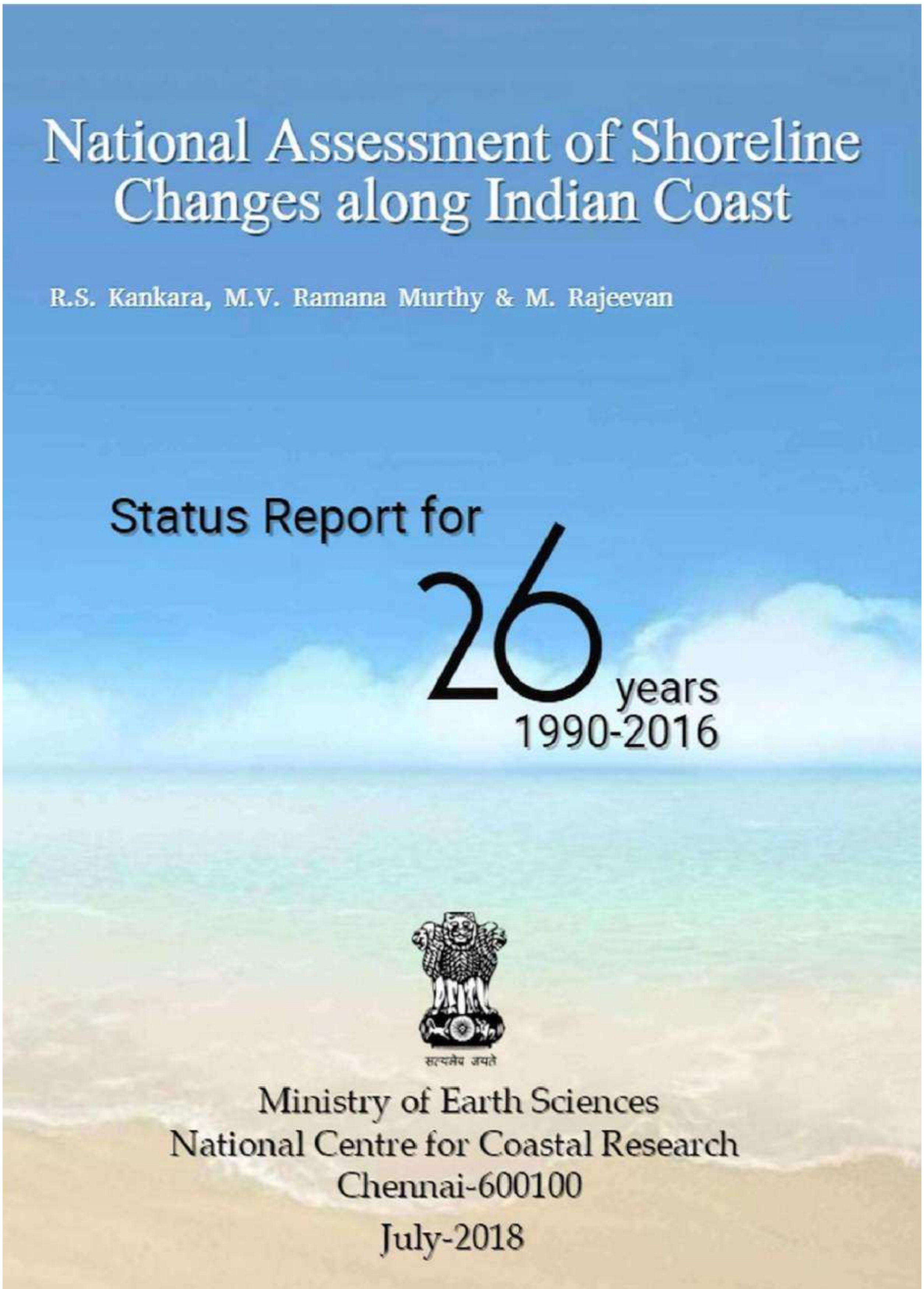
Provisioning Service (Function)	Average value 2011Rs	Utilization pattern of turtle
Meat	757/ kg	Olive ridley, green turtle, hawksbill turtle, leather back
Fat (oil, soap)	41800 / turtle	Olive ridley, green turtle, hawksbill turtle
Stuffed	19614/ turtle	Olive ridley, green turtle, hawksbill turtle
Egg	172/ dozen	Olive ridley, green turtle, hawksbill turtle, leather back
Shell (carapace)	1601/ turtle	Olive ridley, green turtle, hawksbill turtle
Shell - Ornamental resource (bracelet, ring, necklace, hairdip)	102484/ turtle	hawksbill turtle
Skin (Leather)	930/ turtle	leather back

Note: average weight and eggs / year: Olive ridley - 36 kg /204 eggs; Green turtle - 136 kg/ 300 eggs, Hawksbill - 55 kg/ 216 eggs; Leatherback - 499 kg/ 276 eggs (Fisheries Department); meat-75% weight taken in account, fat – 15 litre / turtle converted to approximate amount used in soap and oil.

Turtle	Average value / turtle 2011Rs	Function includes in Average value / turtle
Olive ridley	32377	livelihood consumption (meat, egg) + commercial value (oil, soap, shell, stuffed)
Green turtle	52110	livelihood consumption (meat, egg)+ commercial value (oil, soap, shell, stuffed)
Hawksbill turtle	86348	livelihood consumption (meat, egg) +

		commercial value(Ornamental resource (bracelet, ring, necklace, hairclip), oil, soap, shell, stuffed)
Leather back	288193	livelihood consumption (meat, egg) + commercial value (leather)


National Assessment of Shoreline Changes along Indian Coast
R.S. Kankara, M.V. Ramana Murthy & M. Rajeevan
Status Report for 26 years
1990-2016
सत्यमेव जयते
Ministry of Earth Sciences
National Centre for Coastal Research
Chennai-600100
July-2018



National Assessment of Shoreline Changes along Indian Coast

R.S. Kankara, M.V. Ramana Murthy & M. Rajeevan

Status Report for 26 years 1990-2016

सत्यमेव जयते

Ministry of Earth Sciences
National Centre for Coastal Research
Chennai-600100

July-2018

National Assessment of Shoreline changes along Indian Coast: Status report for 26 years (1990 - 2016)

NCCR PROJECT TEAM MEMBERS

1	Dr. M. V Ramana Murthy, Director & Scientist-G, NCCR
2	Dr. R. S Kankara, Group Head & Scientist F, CP & SM Group, NCCR
3	Dr. S. Chenthamil Selvan, Project Scientist-I
4	Mr. K. Prabhu, Project Scientist-I
5	Mr. B. Rajan, Senior Research Fellow
6	Mr. S. Arockiraj, Senior Research Fellow
7	Mrs. S. Dhanalakshmi, Senior Research Fellow
8	Miss. Padmini G, Senior Research Fellow
9	Dr. V. Noujas, Project Scientist-I
10	Miss. M. Umamaheswari, Senior Research Fellow
11	Mr. S. Sathish, Project Scientist-I

EXPERT COMMITTEE

1	Dr. Shailesh Nayak, Former Secretary, MoES New Delhi	Chairman
2	Dr. Ashok Kumar Saxena, Project Director, ICZMP, Gujarat	Member
3	Dr. Ajit Pattnaik, Project Director (Retd), ICZMP, Odisha	Member
4	Sh. Arvind Kumar Nautiyal, Director, MoEF & CC, New Delhi	Member
5	Sh. Sanjay Kumar Singh, Director, CWC, MoWR, RD&GR, New Delhi	Member

DISCLAIMER

This report is part of series of reports that includes text summarizing methods, results, in addition to maps illustrating zones of shoreline change. Zones of shoreline change are being published for the purpose of coastline characterization. The report / maps are not intended to be equated to either as revenue maps of the respective State/ UT/ Government agencies or as the topographic maps of the Survey of India. The maps conform to the National Map Policy dated May 19, 2005 of the Ministry of Science and Technology, Government of India.

CITATION:

R.S. Kankara, M.V. Ramana Murthy and M. Rajeevan (2018), National Assessment of Shoreline changes along Indian Coast - A status report for 26 years 1990-2016. NCCR Publication, 2018, available at NCCR Web site http://www.nccr.gov.in

Contact:

National Centre for Coastal Research (NCCR)
Velacherry-Tambaram Main Road, Pallikkaranai, Chennai - 600100, India
Tel: +91 44 66783599 Fax: +91 44 66783487
E-mail: kankara@nccr.gov.in

डॉ. एम. राजीवन
DR. M. RAJEEVAN

सचिव
भारत सरकार
पृथ्वी विज्ञान मंत्रालय
पृथ्वी भवन, लोदी रोड़, नई दिल्ली-110003
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
PRITHVI BHAVAN, LODHI ROAD, NEW DELHI-110003

PREFACE

The coastal zone of the world is in constant change due to natural and anthropogenic activities. Natural processes such as waves, tides, littoral currents, sea-level rise, severe storm events etc., have influence on shoreline changes at local and regional scales. While, human activities further aggravate these changes, as they interrupt the natural coastal processes and modify the sediment transport, which leads to rapid changes in the coastline.

The coastline of India is undergoing changes due to various anthropogenic and natural interventions. Population explosion along the coastal area has added to an increase demand for coastal resources. Precise information on shoreline changes is essential to address the various coastal problems such as coastal erosion, closure of river / lagoons /creeks mouths, etc. Thorough understanding of Long-term shoreline change, its behaviour, extent, etc are required before implementing any coastal protection scheme. It is also important to understand the causes of erosion to undertake proper safeguards in building structures, and infrastructure in eroding coastal areas. Coastal managers and policy makers need accurate information on long term shoreline changes before implementing any structure on coast.

The National Centre for Coastal research, Chennai an attached office of Ministry of Earth Sciences is engaged in mapping the shoreline changes along Indian coast to enhance the country's preparedness to face coastal hazards like storm-surges, tsunami etc and to guide the sustainable coastal development. Now NCCR has prepared a status report on shoreline changes for the period 26 years (1990 to 2016) using 9 shoreline data sets i.e. year 1990, 2000, 2006, 2008, 2012, 2013, 2014, 2015 and 2016. It provides details of shoreline changes, 3 types of map, shoreline vulnerability for erosion /accretion, land loss / land gain etc for entire mainland coast of India. These maps will be available online for each of the coastal state/ UT on the NCCR's website.

I congratulate Dr. M. V. Ramana Murthy, Director, NCCR, Dr. R. S. Kankara, Head, Coastal Processes and Shoreline Management Group, NCCR, Project Team and expert committee for bringing out the status report on Shoreline changes along Indian coast for the period of 1990 -2016. I also thank Dr. Shailesh Nayak, Former Secretary, MoES for conceptualising this important activity and reviewing the mapping work.

I hope this information will be very useful to coastal managers and other stakeholders in identifying critical area for coastal management to safeguard property and population living in coastal areas.

(M. Rajeevan)

Tel. : +91-11-24629771, 24629772 ☐ Fax : +91-11-24629777 ☐ E-mail : secretary@moes.gov.in

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SHORELINE MAPS

East coast of India		
Sl. No	**State**	**Number of maps (1:25,000)**
1	Tamil Nadu & Puducherry	80
2	Andhra Pradesh	89
3	Odisha	46
4	West Bengal	29
West coast of India		
5	Kerala	55
6	Karnataka & Goa	32
7	Maharashtra	45
8	Gujarat and Daman Diu	150
	Total Numbers	**526***

* One sample map for each state is included in this report for reference.

ABBREVIATIONS

CPDAC	Coastal Protection and Development Advisory Committee
DSAS	Digital Shoreline Analysis System
EPR	End Point Rate
ESRI	Environmental Systems Research Institute
ETM+	Enhanced Thematic Mapper Plus
GCP	Ground Control Point
GIS	Geographical Information System
GPS	Global Positioning System
HTL	High Tide Line
HWL	High Water Line
LISS-III	Linear Imaging Self Scanning Sensor III
LISS-IV	Linear Imaging Self Scanning Sensor IV
LRR	Linear Regression Rate
MHW	Mean High Water
NNRMS	National Natural Resource Management System
NOAA	National Oceanic and Atmospheric Administration
NRSC	National Remote Sensing Centre
PAN	Panchromatic
PCA	Principal Component Analysis
TM	Thematic Mapper
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
WGS	World Geodetic System
WLR	Weighted Linear Regression Rate

MINISTRY OF EARTH SCIENCES
National Centre for Coastal Research, Chennai

National Assessment of Shoreline changes along Indian coast (1990 - 2016)

EXECUTIVE SUMMARY

Beach erosion is a chronic problem along many shores of the Indian coast. As coastal population continues to grow and community infrastructures are threatened by erosion, there is increased demand for accurate information regarding past and present trends and rates of shoreline movement. There is also a need for a comprehensive analysis of shoreline movement that is inconsistent from one coastal region to another. To meet these national needs, the National Centre for Coastal Research (NCCR) is carried out a study on shoreline changes along mainland of India. One purpose of this work is to develop standard, repeatable methods for mapping and analyzing shoreline movement so that systematic periodic updates on shoreline changes, coastal erosion hotspots, land gain/ loss etc. can be made for Indian coast.

In the case of the analysis of shoreline change along Indian coast, the shoreline proxy is interpreted as wet/dry line in sandy shore, vegetative line and sea shore facing direction of seawall. This report, summarizes the methods of analysis, interprets the results, provides information on shoreline changes for the period of 1990 to 2016, and rates of change. Shoreline change analyses are based on a comparison of different shoreline positions digitized from satellite images. The shorelines position covers a variety of time periods ranging from 1990 to 2016. Long-term rates of change are calculated using all 9 different shorelines positions i.e. for the year 1990, 2000, 2006, 2008,2012, 2013, 2014, 2015 and 2016. The rates of change presented in this report represent conditions up to the date of the most recent shoreline data and therefore are not intended for predicting future shoreline positions or rates of change. The Indian mainland was analyzed separately in a state-wise manner for the purpose of reporting regional trends in shoreline change rates.

About 6031 km long coastline was mapped in 1:25,000 scale to analyse the temporal shoreline changes during 1990 to 2016 using 9 data sets. The results are classified in three categories i.e. erosion, stable and accretion. Overall, about 34% of coastline is under varying degree of coastal erosion, 28% is of accreting nature condition and the remaining 38% falls stable state. The state wise analysis suggests that the more that 40% of erosion is noticed in four states/UT i.e. West Bengal (63%), Pondicherry (57%), Kerala (45%) and Tamil Nadu (41%) coast. While accretion is exceeding to 40% along Odisha (51%) and Andhra Pradesh (42%) coast. The west coast of India (except Kerala) is mainly stable condition, along with isolated pockets of eroding coast. Land loss and land gain analyses revealed that West Bengal coast has lost about 99 sq km land during last 26 years. The shoreline changes along with infrastructure details, ports, industries, anthropogenic activities, are also mapped. 526 maps are prepared for entire Indian coast for identifying the vulnerable coastal areas in 1:25000 scale along with 66 district maps, 10 state /UT maps. These maps shall be updated regularly as a part of coastal change system project. The project is aimed to generate the systematic information on coastal changes at various temporal scales, its nature, and extent, needed to evolve better management solutions.

MINISTRY OF EARTH SCIENCES
National Centre for Coastal Research, Chennai

National Assessment of Shoreline changes along Indian coast (1990 - 2016)

1. Introduction

The shoreline is constantly influenced by sea level variations, climate and ecosystems that occur over a wide range of time-scales. The combination of natural and manmade activities often exacerbates the shoreline change and increases the risk factors to coastal community. Shoreline change is one of the three identified environmental concerns considered for the developmental activities such as ports, harbour, fishing jetties and embankment facilities. The changing position of shoreline over time is of elemental importance to coastal scientists, engineers, and managers for coastal management and engineering design for coastal development. Precise shoreline information is required for the design of coastal protection, structures calibration/verification of numerical models, assessment of sea-level rise, preparation of hazard zones, formulation of policies, the regulation of coastal developmental activities, etc. A systematic long-term shoreline change study can provide information on shoreline re-orientation due to structures, changes in beach width, land loss, land gain and historical rate of changes.

Major causes for shoreline change

Shoreline is subject to change due to natural and manmade activities (P. Bruun and B. U. Nayak, 1980). Some of the changes are summarized below:

Natural Causes

1. Action of Waves: Waves are generated by offshore and nearshore winds, which blow over the sea surface and transfer their energy to the water surface. As waves move towards the shore, waves break, and the turbulent energy is released to the water column. This energy stirs up and moves the sediments deposited on the seabed.
2. Winds: Wind act not just as a generator of waves, but also aids in the landward movement of dunes (Aeolian erosion).
3. Tides: Tides are rise and fall in water elevation due to the attraction of water masses by the moon and the sun. During high tides, the energy of the breaking waves is released higher on the foreshore.
4. Nearshore currents: Sediments scoured from the seabed are transported away from their original location by currents. The transport of (coarse) sediments defines the boundary of coastal sediment cells, i.e. relatively self-contained system within which (coarse) sediments stay. Currents are generated by winds, tides (ebb and flood currents), wave breaking at an oblique angle with the shore (longshore currents), and the backwash of waves on the foreshore (rip currents). All these currents contribute for shoreline changes.
5. Storms: Storms generate storm surges and high energy waves. Combined with high tides, storms may result in catastrophic damages. Besides damages to coastal infrastructure, storms cause beaches and dunes to retreat tens of meters in a few hours.

6. Sea Level Rise: Sea level has risen about 40 cm in the past century and is projected to rise another 60 cm in the next century. Sea level has risen nearly 110 meters since the last ice age. Due to global warming, average rise of sea level is of the order of 1.5 to 10 mm per year. It has been observed that sea level rise of 1 mm per year could cause an inundation of the order of about 0.5 m per year (IPCC report).

Anthropogenic Causes

Human influence, particularly urbanization and economic activities, in the coastal zone has turned coastal erosion into a problem of growing intensity. Anthropological effects that trigger shoreline changes are: construction of coastal structures, mining of beach sand, offshore dredging and damming of rivers. Human intervention can alter the natural processes through the following actions:

- dredging of tidal entrances and navigational channels
- construction of harbours and coastal structures such as groins and jetties
- River water regulation works such as damming
- hardening of shorelines with seawalls
- beach nourishment
- Destruction of mangroves and other natural buffers
- Beach sand mining

1.1 Shoreline and its definitions

Coastal scientists and other coastal agencies have been quantifying the shoreline change rates for many decades. There are various definition of shoreline identified and some of them are summarized here.

The line of contact between land and water is defined as shoreline. In other term shoreline is defined as the intersection of a specified plane of water with the shore or beach (e.g., the high water shoreline would be the intersection of the plane of mean high water with the shore or beach).

However, the shoreline approximates the mean high-water line on coast and Geodetic Survey nautical charts and surveys. In Coast Survey usage, the term is considered synonymous with coastline (Shalowitz, 1962).The line delineating the shoreline on National Ocean Service nautical charts and surveys approximates the mean high water line (USACE, 1984).

Apparent shoreline is the line drawn on a map or chart in lieu of a mean high-water line or the mean water level line in areas where either may be obscured by marsh, mangrove, cypress, or other type of marine vegetation. This line represents the intersection of the appropriate datum on the outer limits of vegetation and appears to the navigator as the shoreline (Ellis, 1978).

High-Water Line Mark: A line or mark left upon tide flats, beach, or alongshore objects indicating the elevation of the intrusion of high water. The mark may be a line of oil or scum along shore objects, or a more or less continuous deposit of fine shell or debris on the foreshore or berm. This mark is physical evidence of the general height reached by wave run-up at recent high waters. It should not be confused with the mean high water line or mean higher high water line (Hicks, 1984).

High-water line - Visible in the field and can be identified by the change in grey or colour tone on aerial photographs or satellite imagery (Zhang et al., 2002). This definition makes it more practical when satellite imagery is concerned.

Different proxies for shoreline position are used to analyse the coastal changes. Some of the proxies of shoreline positions are High Water Line (HWL), wet-dry line, vegetation line, dune toe or crest, toe of the beach, cliff base or top and Mean High Water Line (MHWL) etc. Earlier days, High Water Line in Toposheets was also used as one of the shoreline positions.

1.2 Indian coast and its Geomorphology in general

Indian mainland coast includes 9 coastal states and 2 union territories having 66 coastal districts. Morphology of the coast consists of 43% sandy beach, 11% rocky coast, 36% of muddy flats 10% of marshy coast, 97 major estuaries and 34 lagoons (CPDAC Report). There are 13 major ports, 46fishing harbours and 187 minor ports.

Table 1: Coastal geomorphic features of India

Sl. No	State	Landforms and features
		East coast of India
1	Tamil Nadu	Deltas, long narrow beaches, spits, tidal flats, mangroves, coral reefs, sand dunes, Ridge swale complex etc.
2	Andhra Pradesh	Deltas, long narrow beaches, spits, mangroves, cliffs, long sand dunes, Ridge swale complex etc.
3	Odisha	Deltas, long beaches, spits, tidal flats, long sand dunes, ridges etc.
4	West Bengal	Large delta, very thick mangroves, tidal channels, islands, dunes, tidal flat, beaches etc
		West Coast of India
5	Kerala	Estuaries, lagoons, barriers, spits, dunes, tombolo, cliff, beaches etc
6	Karnataka & Goa	Estuaries, spits, sand dunes, tombolo, cliff, wave cut platforms, beaches etc
7	Maharashtra	Estuaries, cliffs, small sand dunes, tombolo, cliff, wave cut platforms, pocket beaches etc
8	Gujarat	Marshy land, tidal flats, estuaries, cliffs, mud flats, mangroves wave cut platforms, beaches etc.

Coastal geomorphology deals with the shaping of coastal features (landforms), the processes at work on them and the changes taking place. The shore is the zone between the water's edge at low tide and the upper limit of effective wave action, usually extending to the cliff base. It includes the foreshore exposed at low tide and submerged at high tide and the backshore extending landward from the normal high tide limit, but inundated by exceptionally high tides or by large waves during storms.

Coastal geomorphology is susceptible to coastal changes and plays an important role in determining the impact of sea-level rise. Every landform offers certain degree of resistance to erosion. For example, rocky coast and wave-cut benches offers maximum resistance. On the other hand, sandy beaches, sand dunes, mudflats, mangroves, etc, show least resistance to sea-level rise.

East coast is mostly dominated by coastal plains and is wider with many large deltas, lagoons, mangroves, long and wide stretches of sand dunes, ridges and beaches are the common features observed along the coast. Along the west coast, most common geomorphic features are rocky coast, headlands, cliffs, estuaries and bays, etc. The general distribution of geomorphic features along the Indian coast is given in Table 1.

1.3 Past studies on Shoreline mapping in India

Several proxies are being used worldwide for shoreline change studies. In India, NCSCM has prepared shoreline change mapsfor few coastal states. The shoreline changes maps were prepared by considering the latest shoreline for year 2010 as a onetime exercise in 1:50,000 scale.

Further, SAC has prepared shoreline change maps with Central Water Commission in the form of Atlas (1; 25000 scale). The major objective of this activity is to prepare a digital shoreline change atlas in GIS environment on 1:25,000 scale using satellite data (1989-91 and 2004-06). This report gives an overview of erosion/accretion by plotting 2 high water line polygons obtained from land use /land cover mapping work carried out at SAC earlier for these two different periods of datasets i.e. 1989-91 and 2004-06.However, these maps don't depict the temporal behaviour and non-linear changes of shoreline, which is very essential for coastal management.

1.4 Shoreline proxies adopted Shoreline mapping at ESSO-NCCR

In 2013 ICMAM has conducted a R&D study on shoreline changes using different proxies and varying datasets and prepared a report on methodology for shoreline change mapping. In this report, ICMAM proposedhigh Water line (HWL) mark as shoreline position considering the varying coastal features, other variability and limitations of RS data along Indian coast.In August 2014, a committee of experts from ICMAM, INCOIS and NCESS evaluated the results and recommended that,

- In sandy shore,**"wet/dry line"** which is clearly identifiable from all images was considered as shoreline proxy. This wet/dry lineis equivalent to **high water line (HWL)** mark from all satellite images. The identification of the feature **"wet/dry line"** from the images is as follows: on a rising tide, it is equal to maximum run up line, and on falling tide, it is equal to part of beach which is still wet, but it may be beyond the instantaneous run up limit.
- **Vegetative line** is considered as shoreline proxy, where there is no sandy beach. The waves directly interact with the vegetations along the coast. Seashore facing direction of vegetative limits is demarcated as shoreline proxy and it can be clearly interpreted with the satellite images.
- In case of **artificial structures** (seawalls), the sea shore facing direction of seawall is considered as shoreline position.In rocky coast, cliff base or sea shore edge is considered as shoreline position.

1.5 Scope of long-term shoreline change mapping

The knowledge on shoreline changes, its behaviour, erosion in historical perspective and related morphological characteristics are primary requirements for coastal development and shore protection projects. Though some attempts are made, systematic information of Indian coast based on widely accepted, standardized method of shoreline change is not available. Therefore, in XII plan(October 2012), MoES (ICMAM) was entrusted the task of studying shoreline changes along the Indian coast using remote sensing, field investigation, Numerical modelling and GIS. The main objectives of this work are:

- To assess the consistency and generate reliable information of complex systems of the Indian coast using a standard method
- To prepare shoreline change maps using standard protocol (1:25000 scale) for the entire coast.
- To carry out shoreline change analysis at state and district levels.
- To estimate annual land loss / land gain due to shoreline changes.
- To initiate a web based coastal service on annual shoreline changes along the Indian coast.

2. Data used

Satellite data sets are used as the primary data source. The multi-temporal satellite data such as Landsat TM, ETM+, IRS-P5 (Cartosat-1), IRS-P6 (LISS-III) and (LISS-IV) were used to calculate the shoreline change for different years (Table 2).

Table 2: Details of satellite data used

List of Image	Pixel Size(m)	Date	Source
Landsat 5 TM	30.0	1989-1992	USGS
Landsat 7 ETM+	30.0	1999-2001	USGS
IRS P5 (Cartosat-1) PAN	2.5	2005-2006	INDIAN
IRS P6 (Resourcesat-1) - (LISS-III)	23.5	2008	INDIAN
Resourcesat 2 - (LISS-IV)	5.8	2012	INDIAN
Resourcesat 2 - (LISS-IV)	5.8	2013	INDIAN
Resourcesat 2 - (LISS-IV)	5.8	2014	INDIAN
Resourcesat 2 - (LISS-IV)	5.8	2015	INDIAN
Resourcesat 2 - (LISS-IV)	5.8	2016	INDIAN

3. Methodology

Shoreline evolution is one of the most significant factors in analyzing the change rate. There are several approaches to calculate the rates of shoreline change, such as numerical models and remote sensing technique. Remote sensing technique and GIS technology are considered as dominant tools for quantifying the shoreline change on temporal scale (Nayak. S., 2002). By integrating the modern techniques of remote sensing and GIS, rates of shoreline change would be easily and quickly determined for any given area. The methodology adopted for shoreline change calculation is shown in the flow chart (Figure 1).

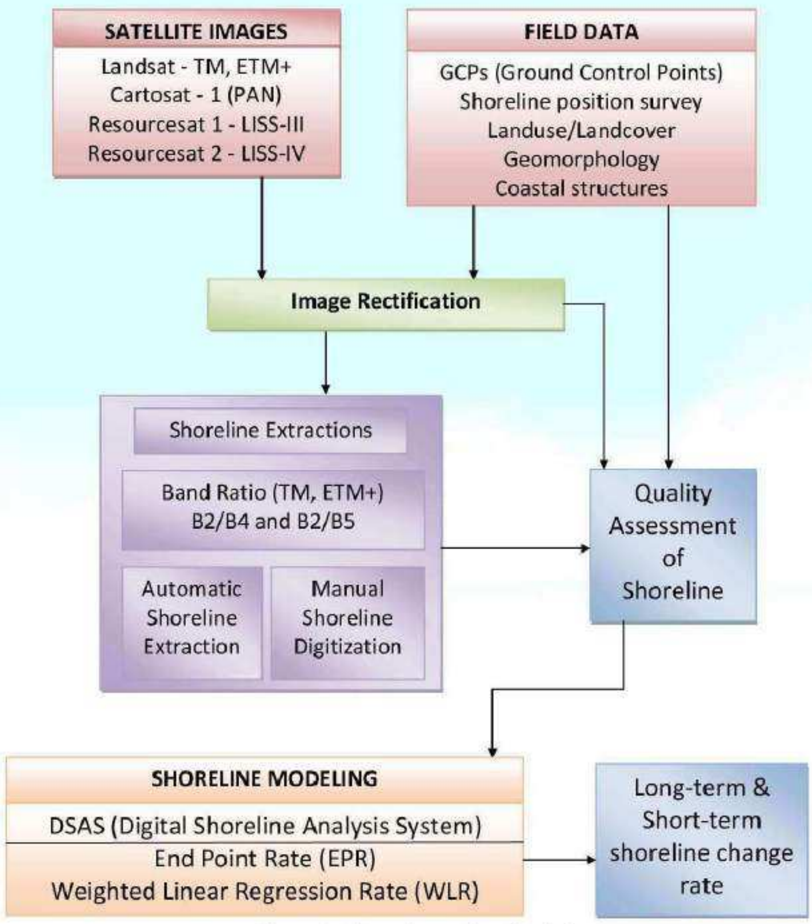


Figure 1: Flow chart of methodology

3.1 Determination of shoreline from Remote Sensing and fielddata

Determination of shoreline position from satellite data is very subjective due to limiting factors such as, different ranges of tide induced variability, variations in meteorological conditions, inequalities in data resolution, seasonal setup and scaling of RS data during different periods of data acquisition. In the past, the researchers had used various proxies such as high tide line (HTL) (Fisher and Overton, 1994; Stockdon*et al.*, 2002), high water line (HWL) (Fenster and Dolan, 1999), wet-dry line (Overton *et al.*, 1999), vegetation line (Hoeke*et al.*, 2001), dune toe or crest (Stafford and Langfelder, 1971), toe or Berm of the beach (Norcross *et al.*, 2002), cliff base or top (Moore *et al.*, 1998) and mean high water (MHW) line (Galgano and Leatherman, 1991). However, it becomes subjective to extract these proxies in practical sense due to varying geomorphology of coastal environment. Some of the shoreline proxies which are commonly used in shoreline extraction are shown in Figure 2.

Figure 2: Shoreline proxies used for shoreline extraction. **A**-Sand dunes with vegetative cover. **B**-Vegetative line. **C**-Riprap structures in case there is no sandy shore. **D**-High water line (HWL). **E**- Debris brought by the waves.

3.2 Shoreline extraction from satellite data

Before analyzing the shoreline change rate, it is necessary to define the shoreline proxy for any particular scenes used in the analysis. Advantages and limitations of the coast have to be understood before defining the shoreline position within the available data source. Same proxy cannot be used for the entire coast due to different geomorphological conditions.

In the present study, semi-automated method (automatic and manual digitization) was carried out to extract the shoreline. It can reduce the pixel misinterpretation error which is more common in automatic method. The shoreline proxy used in the analysis also varies from place to place. Therefore, semi-automated method is the best suited for shoreline extraction.

3.3 GIS database for shoreline mapping

The 'GEODATABASE" term describes any information system that integrates, stores, edits, analyzes, shares and displays geographic information for informed decision making. GDB supports all the different elements of GIS data used by ArcGIS. The shoreline GDB includes the attribute fields such as ObjectID (a unique number assigned to each transect, shape, shape length, ID, date (original survey year) and uncertainty values for calculating the rate. The other information stored in GDB format are shoreline rate file, field photographs, co-ordinates, base map information and sediments locations.

3.4 Shoreline change calculation

There are many statistical methods used by DSAS to calculate the shoreline change rate. These methods are End Point Rate (EPR), Linear Regression Rate (LRR) and Weighted Linear Regression (WLR). Of these methods, EPR and WLR are used for the analysis. DSAS is purely a statistical approach which gives output based on input parameters such as date and year.

3.4.1 Periodic changes

End point rate (EPR)

The minimum requirement is 2 data sets of shoreline over a time to compute shoreline movement. This is a simple and popular approach adopted to calculate the shoreline change rates by dividing the distance of shoreline movement by time elapsed as given in Figure 3.

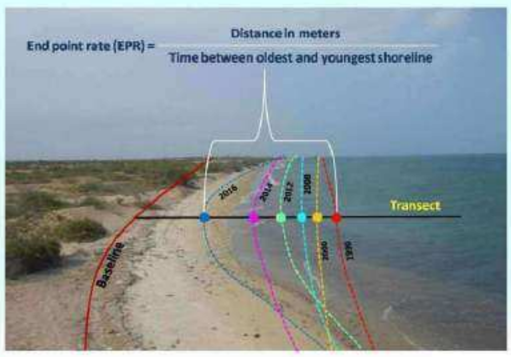


Figure 3: Shoreline change: End point rate method(distance between the 1990 and 2016 shorelines divided by the span of time elapsed between the two shoreline positions; all other shoreline data are ignored in this computation).

3.4.2 Cumulative changes

Weighted linear regression rate (WLR)

The cumulative shoreline changes are computed considering the nine series of data sets. These rates are calculated by determining a linear regression rate-of-change (fitting a least-square regression lines) for point/transect along the coast. Further, a weightage was attached to shoreline data considering the measurement and positional uncertainties involved in obtaining the data. Fine resolution/quality data sets are given greater emphasis or weightage towards determining a best-fit line in comparison with unreliable or poor data sets, i.e. the regression line can be placed in such a way that the sum of the squared residuals is minimized.

The weight (w) is defined as a function of the variance in the uncertainty of the measurement (e): **$w = 1/(e^2)$,** where, e = shoreline uncertainty value. The uncertainty and shoreline position at these transects are used to calculate the rate-of-change statistics. Figure 4 shows the shoreline positions of a particular transect plotted with respect to time. The error bar in shoreline measurement point is obtained after adding the weighted values to each shoreline position.

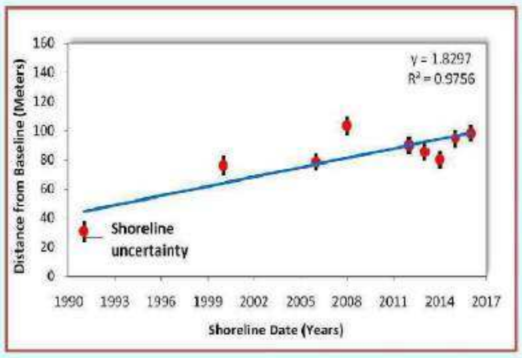


Figure 4: Shoreline change by the weighted linear regression rate method (determined by plotting the shoreline positions with respect to time and calculating the linear regression equation of y. The slope of the regression line is the rate).

3.5 Uncertainty in shoreline measurement

Further the accuracy of shoreline positions extracted from remote sensing data is influenced by several factors such as positional uncertainties (Seasonal error, & Tidal fluctuation) and measurement uncertainties (Digitizing, Pixel, & Rectification).

There are issues in shoreline mapping in wider intertidal zones. The extraction of "HWL" or "wet/dry line" from various images has potential uncertainties and errors with reference to tide and resolution. Therefore, the same may be accounted while considering these positional and measurement uncertainties, which may be within in the limitations of the data itself.

Positional Uncertainties: related to the features and phenomena that reduce the precision and accuracy of defining a shoreline position from a given data set such as Seasonal error (E_s), and Tidal fluctuation (E_{td}).

Measurement Uncertainties: related to the skill and approach such as Digitizing error (E_{d}) Rectification error (E_r) and Pixel error (E_p)

Finally, overall total uncertainty value has been estimated for each shoreline by accounting for both positional and measurement uncertainties as:

$$Et = \pm\sqrt{E_s^2 + E_{td}^2 + E_d^2 + E_P^2 + E_r^2} \longrightarrow Eqn\ 1$$

This approach considers varying rate of changes between each dataset by fitting a least-square regression line for all datasets. In this approach, high resolution data sets are given greater emphasis or weightage towards determining a best-fit line in comparison with unreliable or poor data sets.

The total uncertainties considered in the analysis are given in Table 3.

Table 3: List of uncertainties used in the analysis

Errors	Consideration	Uncertainty Value
Tidal error	Tidal values are taken from the tide table and tidal stations along the coast. The tidal value differs from place to place based on the station.	Tide range from the nearest station.
Seasonal error	Seasonal error is the horizontal distance along the coast. This error mainly depends on the coastal slope. The coasts are either steep or gentle. Taking this factor in to account the seasonal error to be considered.	based on the slope. (availability of slope data is a question; or 5 - 10 m based on the regions).
Digitizing error	Digitizing the shoreline is a difficult task. Digitizing the shoreline position by the same analyst may change when he does it again. After considering all the factors, the error is fixed.	Half of the pixel size is considered.
Rectification error	Rectification error is the error obtained from the ortho-rectification process. The RMSE error thus obtained during rectification is considered as error value.	RMSE value (the rectification accuracy should be maintained with in a pixel).

3.6 Field Database

Field work was undertaken for entire coastal region of India, mainly focusing to collection of GCPs, shoreline tracking during satellite pass time, sediment data collection, validation/verification of landuse/landcover and geomorphology.

3.6.1 Shoreline Mapping

Shorelines were tracked for select locations using handheld GPS instrument. Shoreline tracking was carried out mainly during the satellite pass time. The shoreline extracted from satellite imagery is then cross validated with the shoreline tracked from the field. Plate 1 shows the shoreline tracking along Battigavuru coast, Andhra Pradesh.

Plate 1. Shoreline tracking along Battigavuru, Andhra Pradesh

Plate 2. GCP collection at NH-5, Srikakulam, Andhra Pradesh

3.6.2 Collection of Ground Control Points (GCP's)

GCP's were collected to rectify the satellite imagery which is used for shoreline extraction. 15km width from the coast is considered as the boundary for GCP collection. All the GCP's were evenly collected all along the image for minimising the error while extracting the shoreline positions. All the satellite images should be brought into a common projection system (WGS 84) so that the error or shift in the images can be reduced. GCP collection at NH-5, Srikakulam , Andhra Pradesh is shown in Plate 2.

3.6.3 Sediment Sample Collection

About 1050 Sediment samples were collected at various locations along Indian coast (Figure 5). Three samples (foreshore, bermline and backshore) at each location were collected. Position of sampling locations was observed by hand-held GPS. In the laboratory, dead shells were separated from sediments and the mixed saline content was removed from the grains by washing with water. The grain size distribution was carried out using a sieve shaker and it consisted of 8 sieves containing mesh sizes of 75μm, 125μm, 180μm, 250μm, 355μm, 500μm, 1000μm and 2000μm. The statistical parameters such as mean, standard deviation, skewness and kurtosis were computed by (Folk and Ward, 1957) using the GRADISTAT grain size distribution and statistical package (Blott and Pye, 2001).The sediment sample collection in the foreshore at Lakshmipuram, AP is shown in Plate 3.

Figure 5: Locations of sediment samples collected along coastline

Plate 3. Sediment collection at Lakshmipuram, Andhra Pradesh

3.6.4 Landuse/Landcover feature identification/validation

Management of coastal areas depends on understanding the different uses of coastal land and the physical processes impacting on the coast. Hence delineation of landuse and landcover is important for understanding the impact of shoreline changes. The land features thus digitized from imagery is then classified based on the NRSC classification schemes. Resourcesat-2 (LISS-IV) data were used to classify the land features and results were validated with field observation at select locations.

3.7 Other Observations

3.7.1 Beach Width

The width of the beach changes continually because beaches are naturally dynamic, and their width can be altered by human activities or natural processes.

Plate 4. Beach during non-monsoon season at Midalam, Tamil Nadu

Plate 5. Beach during monsoon season at Midalam, Tamil Nadu

Measuring the beach width gives indirect evidence about the erosion process at any given coastal sites. In most of the places beaches erode during monsoon season, and again regain in post-monsoon season (Plates 4 & 5). Therefore, understanding of these features is very important to precisely measure the shoreline from satellite images.

3.7.2 Artificial Structures

The major artificial structures adopted for coastal protection are seawalls and groins. The jetties, fishing harbours and ports are constructed at many coastal sites for development purpose. Construction of any structure on the coast naturally causes erosion in the downdrift side and accretion in the updrift side. Extensive field work was carried out for mapping these artificial structures to calculate the shoreline positions precisely (Plates 6 to 8).

Plate 6. Damaged seawall at Thengaipattinam, Tamil Nadu

Plate 7. Pier at Valiathura, Kerala

Plate 8. Seawall at Chellanam, Kerala

3.8 Quality Check

There are several geospatial standards, viz. Natural Resources Information System (NRIS), National Natural Resources Management System (NNRMS), National Spatial Data Infrastructure (NSDI) and National Urban Information System (NUIS), are being used in India. These standards were used for quality check at NCCR in integrated manner to suite our requirement. The broad points are given below:

- NCCR has prepared a Standard Operating Protocol (SOP) to generate shoreline change map at 1:25000 scale.
- Image rectification, shoreline digitization, and map accuracy were followed as per NNRMS standard. The rectification accuracy is maintained within a pixel using 2nd order polynomial method.
- The planimetric shoreline map accuracy was maintained within 1mm in scale at 90% confidence interval and classification accuracy of 90% at 90% confidence interval.
- Considering the uncertainties, shoreline change rate was analyzed using weighted linear regression rate method along with 85% confidence interval (DSAS manual).

3.9 Mapping of Shoreline Change

The results obtained from the analysis of shoreline changes are in the form of numbers i.e., ±m/yr, where + is for accretion, and - is for erosion. These quantitative results are plotted in GIS environment using standard mapping format in 1:25000 scale. However, mapping requires classifications of accretion/erosion rates in sub-classes considering the magnitude of changes. The classification of shoreline changes is further a subjective aspect. We have classified the shoreline change rates into seven classes (Table 4) (Kankara et al., 2014). The marginal change of ±0.5m/yr is considered as no change or stable coast, in view of uncertainties in the data.

Table 4: Shoreline classification schemes used in the analysis

Classification	Rate (m/year)	Colour Schemes
High Erosion	< -5.0	
Moderate Erosion	-5.0 to -3	
Low Erosion	-3.0 to -0.5	
Stable Coast	-0.5 to 0.5	
Low Accretion	0.5 to 3.0	
Moderate Accretion	3.0 to 5.0	
High Accretion	> 5.0	

4. Status of shoreline changes along the Indian coast

4.1 Status of coastal erosion along the Indian mainland

About 6632km long shoreline (in 1:25000 scale) distributed among nine coastal states and two union territories was analyzed for the period 1990-2016 to estimate the shoreline change i.e., erosion, accretion and stable. Coastal erosion has become one of the most alarming threats in varying pockets along the Indian coast. Shoreline length used in the analysis is the shoreface length (excluding the interior parts of river / creeks) obtained from Resourcesat-2, LISS-IV satellite data (by zooming in 1: 15000 scales). The shoreline analysis suggests that 34% of coast is eroding, 28% is accreting and 38% is in stable state (Table 5).

Table 5:Summary of shoreline changes along the Indian coast

Sl No		States	Shoreline used for mapping (in km)*	Status of the coast					
				Erosion		Stable		Accretion	
				km	%	km	%	km	%
1	West Coast	Gujarat, Daman & Diu	1701.78	524.84	31	741.98	43	434.96	26
2	West Coast	Maharashtra	739.57	178.26	24	472.67	64	88.64	12
3	West Coast	Goa	139.64	16.82	12	95.58	68	27.24	20
4	West Coast	Karnataka	313.02	70.02	22	151.16	48	91.84	30
5	West Coast	Kerala	592.96	263.04	45	201.52	34	128.40	21
6	East Coast	Tamil Nadu	991.47	407.05	41	353.56	36	230.86	23
7	East Coast	Pondicherry	41.66	23.80	57	14.63	35	3.23	8
8	East Coast	Andhra Pradesh	1027.58	272.34	27	320.98	31	434.26	42
9	East Coast	Odisha	549.50	153.80	28	113.52	21	282.18	51
10	East Coast	West Bengal	534.35	336.52	63	68.78	13	129.05	24
Total			6631.53	2246.49		2534.38		1850.66	
%				34		38		28	

* Length of shoreline estimated from imageries(1:25000 scale) excluding river /creak mouths etc.

The state-wise analysis suggests that in the West Bengal (63%) and Pondicherry (57%) coasts, erosion exceeds more than 50%, followed by Kerala (45%) and Tamil Nadu (41%). Odisha (51%) is the only coastal state which is having more than 50% of accretion, followed by Andhra Pradesh with 42%. Apart from Kerala coast, coasts in other states on the west coast of India fall in stable condition. More than 50% of West Bengal and Pondicherry coasts are under erosion, followed by Kerala (45%) and Tamil Nadu (41%). Odisha is the only coastal state which has more than 50% accretion followed by Andhra Pradesh with 42%. The state-wise details of shoreline change status are given in Tables 6 & 7.

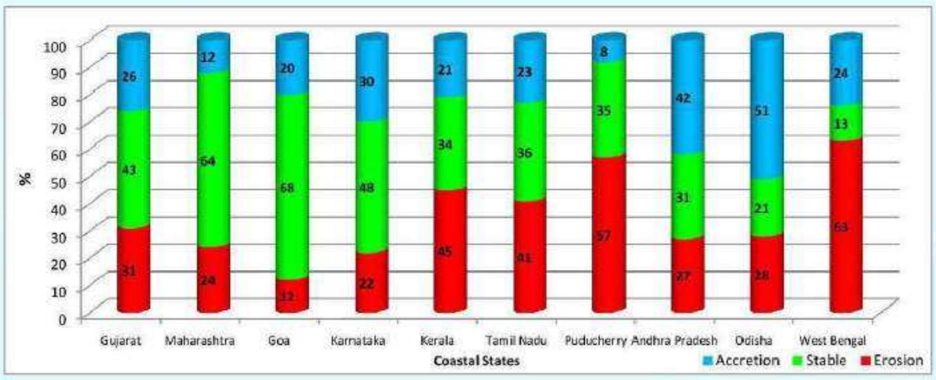


Figure 6: Shoreline change status of Indian coastal states in percentage

Table 6: Erosion-stable-accretion status along the west coast of India

SL No	State	Coast Length (in km)	Coast length (in km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	Gujarat, Daman and Diu	1701.78	30.96	46.04	447.84	741.98	357.64	50.06	27.26
2	Maharashtra	739.57	2.54	9.38	166.34	472.67	78.22	5.38	5.04
3	Goa	139.64	0.08	1.46	15.28	95.58	23.00	3.52	0.72
4	Karnataka	313.02	2.20	4.46	63.36	151.16	81.64	8.12	2.08
5	Kerala	592.96	5.30	8.98	248.76	201.52	96.50	14.68	17.22
Total		3486.97	37.62	74.48	850.82	1662.392	727.44	78.04	56.18
%			1	2	24	48	21	2	2

Table 7: Erosion-stable-accretion status along the east coast of India

SL No	State	Coast Length (in km)	Coast length (in km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	Tamil Nadu	991.47	14.66	36.65	355.74	353.56	194.27	23.96	12.63
2	Puducherry	41.66	0.00	0.32	23.48	14.63	1.45	1.78	0.00
3	Andhra Pradesh	1027.58	101.50	32.78	138.06	320.98	273.58	67.18	93.50
4	Odisha	549.50	68.26	30.50	55.04	113.52	138.94	45.60	97.64
5	West Bengal	534.35	173.64	51.96	110.92	68.78	56.26	19.80	52.99
Total		3144.56	358.06	152.20	683.24	871.47	664.51	158.31	256.76
%			11	5	22	28	21	5	8

4.2 Status of land loss and land gain due to shoreline changes

Land loss and gain due to shoreline changes were quantified in square kilometres (sq. km) by geoprocessing shorelines of 1990 and 2016 in GIS environment (Figure 7). The results elucidate significant amount of land either gained or lost during the above time frame. It can be seen that the coastal states of Gujarat, Andhra Pradesh, Odisha and West Bengal have undergone drastic change in the past 26 years. Land gain of greater than 60 sq.km is observed along the states of Gujarat and Odisha. In Andhra Pradesh, Kerala and Tamil Nadu both land gain as well as loss is seen to have occurred simultaneously in significant amounts. Land gain is slightly higher than land loss in Andhra Pradesh and Kerala; however in case of Tamil Nadu it's reverse (land loss is more than gain). States in the Konkan sector along the west coast of India viz., Maharashtra, Goa and Karnataka are seen to exhibit very less changes. Land gain and loss in these states are of the order of 0.55 and 5.84 sq. km respectively. Of all the states maximum land loss is in West Bengal, 99.05 sq. km is seen to have lost by erosion. Over all during 1990 to 2016, about 231.50 sq. km of land is gained by accretion and 234.25 sq. km land is lost by erosion along the Indian mainland.

Figure 7: Land loss/land gain distribution along Indian coast.

4.3 List of Shoreline change maps in 1:25000 scale

The shoreline change maps for both long and short term were prepared in 1:25,000 scale and shall be hosted on NCCR website. These maps are being updated every subsequent year. The details state-wise maps are listed in Table 8 and Gird wise information is listed in **Annexture-1**.

Table 8: Total number of 1:25,000 scale maps along the Indian coast

East coast of India		
Sl. No	**State**	**Number of maps(1:25,000)**
1	Tamil Nadu & Puducherry	80
2	Andhra Pradesh	89
3	Odisha	46
4	West Bengal	29
West coast of India		
5	Kerala	55
6	Karnataka & Goa	32
7	Maharashtra	45
8	Gujarat and Daman &Diu	150
Total Numbers		526

Considering the maximum and minimum values of the shoreline change rate, the shoreline is divided into seven categories as low erosion, moderate erosion, high erosion, stable, low accretion, moderate accretion and high accretion (Figure 8). The status of the shoreline change along with infrastructure details, assessment of erosion, locations likely factor of erosion ports, industries, anthropogenic activities, will also be provided the shoreline change maps. The map will be updated every year. The overall distribution of shoreline change rate along the Indian coast for 1990-2016 is shown in Figure 6.

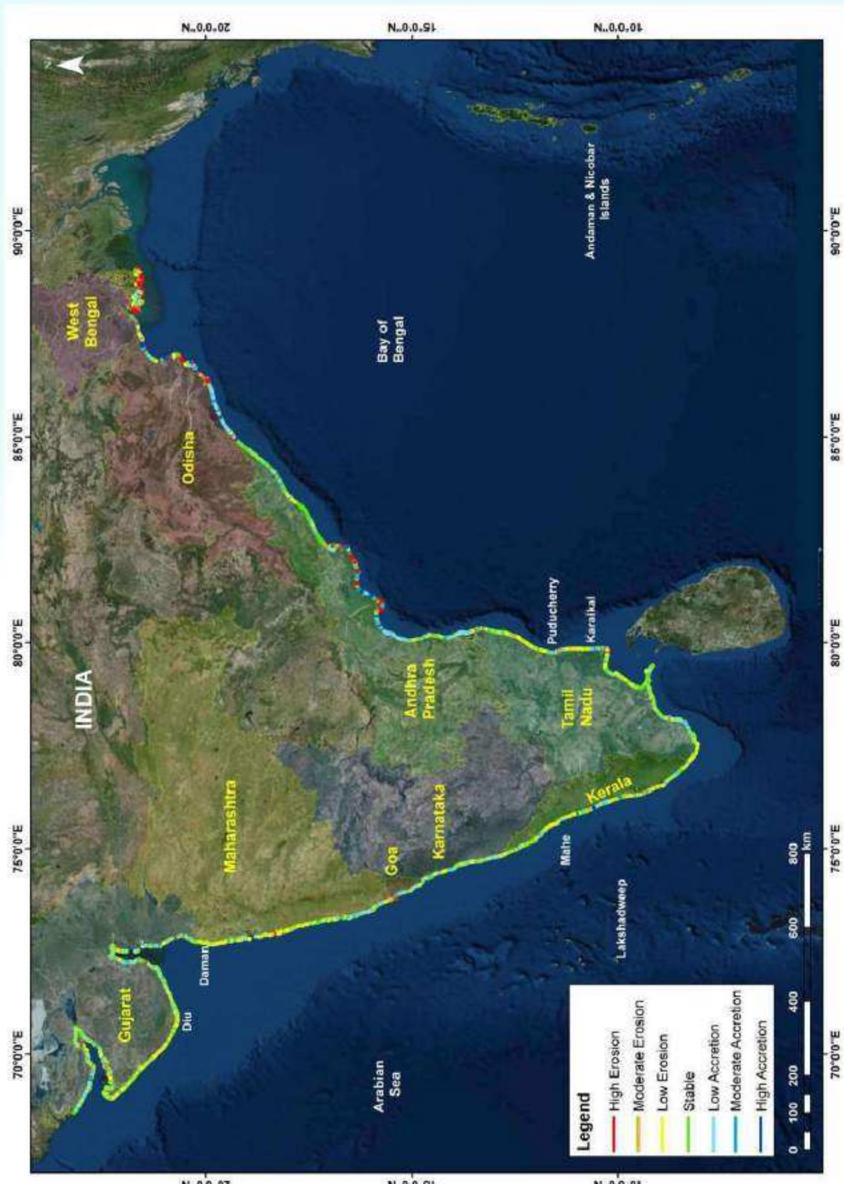


Figure 8: Shoreline change map along Indian coast (1990-2016)

4.3.1 Gujarat, Daman & Diu

The Coastal state of Gujarat is on the western end of Indian peninsula. It is endowed with long coastline of varying geomorphic features, and based on the varied physiographic features, geomorphology, coastal processes and river discharge the coast can be broadly classified into five regions (1) The Rann of Kachchh (2) Gulf of Kachchh (3) The Saurashtra coast (4) Gulf of Khambhat and (5) The south Gujarat coast. The coastlines of the Gulf of Khambhat and Kachchh are tide dominated with tidal mudflats, salt flats, mangroves and salt marshes prevalent all along the stretch. Major rivers like Narmada, Tapti, Mahi and Sabarmati drain into the Gulf of Khambhat to form an estuary. Tidal variation of 8-11m is observed in the coast with strong tidal currents influencing the landforms. Wave dominance can be seen along Saurashtra coast. Sandy beaches, rocky terrace, cliffs, coastal plains and estuary are few of the geomorphic features of the Saurashtra sector. Coral reefs and coral islands in the Gulf of Kachchh are another remarkable aspect of the coast, around 37 species of corals are found here. Human intervention in the form of developments of structure plays a major role in influencing the shoreline change system. Gujarat, because of its strategic location near the Middle East, Africa and Europe is dotted with 49 ports which include 1 major port at Kandla and 48 minor ports. Apart from this, other industrial and developmental activities such as salt industry, cement industry and aquaculture also the landuse and catalyse shoreline changes.

Coastal length of the state constituting 14 coastal districts and 2 union territories is measured to be approximately 1701 km from 2016 satellite imagery. The 1990 to 2016 shoreline change assessment result shows that 43% of the coast is stable, 31% is eroding and remaining 26% is accreting. It is observed that south Gujarat districts of Valsad, Navsari, Bharuch and district of Kachchh exhibit all three (stable, accretion and erosion) conditions.Bhavnagar and Surat coasts are dominated by stable and accretion conditions. Districts of Anand and Ahmedabad in the Gulf of Khambhat are dominated by stable conditions with 57% and 69% of their respective coastal lengths remaining stable. In the Saurashtra sector, viz. Amreli, Girsomnath, Porbandar, DevbhumiDwaraka and Jamnagar, erosion and stable conditions are prevalent. About 66% of Junagadh coast faces erosion. In the case of Union Territory of Daman and Diu are erosion and stable trends are recorded respectively.Erosion hot spots are identified along Bhat, Onjal and Borsri of Navsari district, Bhagwa of Surat and along Degam, Isanpur, Devla and Dhej of Bharuch district. In the Saurashtra sector, erosion is observed along Jaspara,Mithi, Viradi, Thalsar and Gogha of Bhavnagar and in Adri , Navapara of Girsomnath. Regions around Mundra and Kandla, where leading ports operate, are also observed to be eroding. Notable accretion is seen along Nada of Bharuch district and Bhavnagar.

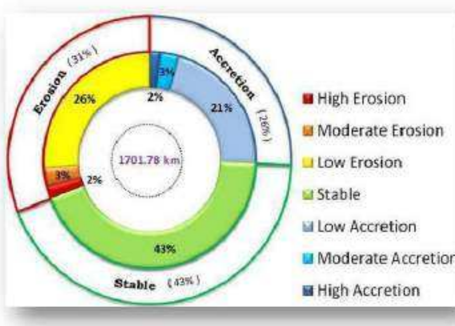


Figure 9: Percentage of shoreline change rate along Gujarat coast.

Table 9: Erosion-stable-accretion status of Gujarat coastal districts

SL No	District	Coast Length (in km)	Coast length (in km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	Valsad	75.46	2.36	3.90	24.78	25.76	14.34	2.44	1.88
2	Navsari	43.32	1.18	3.86	7.20	18.40	9.38	0.66	2.64
3	Surat	42.48	0.00	0.42	4.82	17.62	13.62	5.40	0.60
4	Bharuch	77.32	1.84	4.54	16.64	29.70	20.96	2.56	1.08
5	Anand	59.88	0.28	1.08	13.12	34.18	9.02	1.52	0.68
6	Ahmedabad	77.52	0.64	0.62	3.00	53.32	17.56	1.34	1.04
7	Bhavnagar	173.66	6.04	3.30	27.92	67.40	56.94	9.30	2.76
8	Amreli	57.00	0.16	0.88	22.40	18.68	14.50	0.34	0.04
9	Gir Somnath	114.40	1.42	2.56	46.70	44.72	17.64	0.92	0.44
10	Junagadh	42.98	0.08	4.64	23.48	11.20	3.48	0.10	0.00
11	Porbandar	112.60	0.02	0.38	52.70	54.70	4.48	0.08	0.24
12	Devbhumi Dwarka	228.60	5.26	6.36	80.40	95.54	35.22	3.14	2.68
13	Jamnagar	177.38	5.22	4.68	34.70	87.60	31.48	8.44	5.26
14	Kachchh	386.64	6.42	7.92	78.38	169.66	103.58	12.76	7.92
15	Diu	18.18	0.00	0.82	9.54	5.96	1.82	0.04	0.00
16	Daman	14.36	0.04	0.08	2.06	7.54	3.62	1.02	0.00
TOTAL		**1701.78**	**30.96**	**46.04**	**447.84**	**741.98**	**357.64**	**50.06**	**27.26**

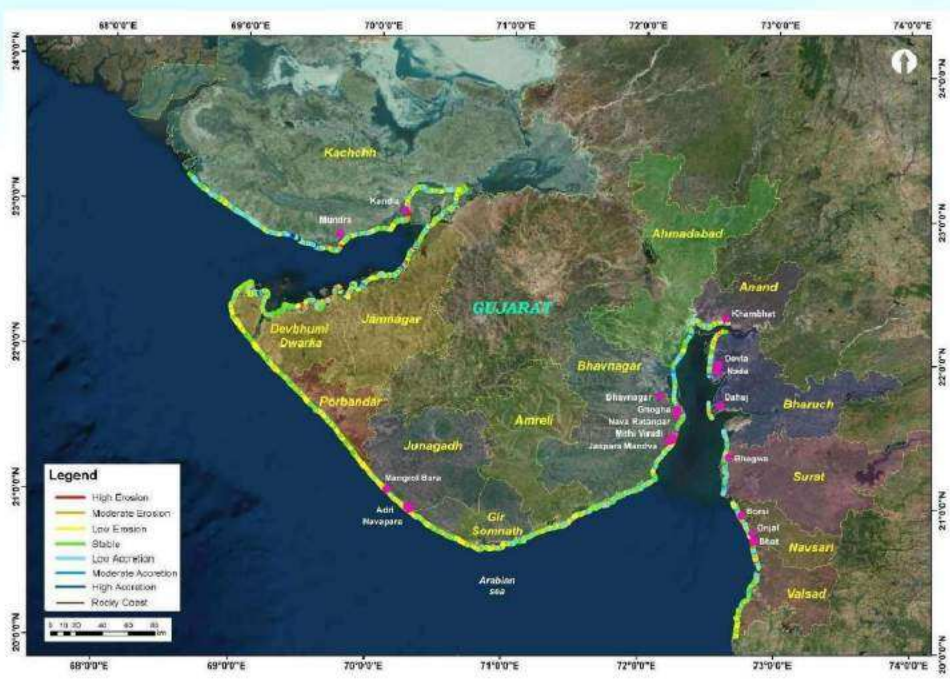
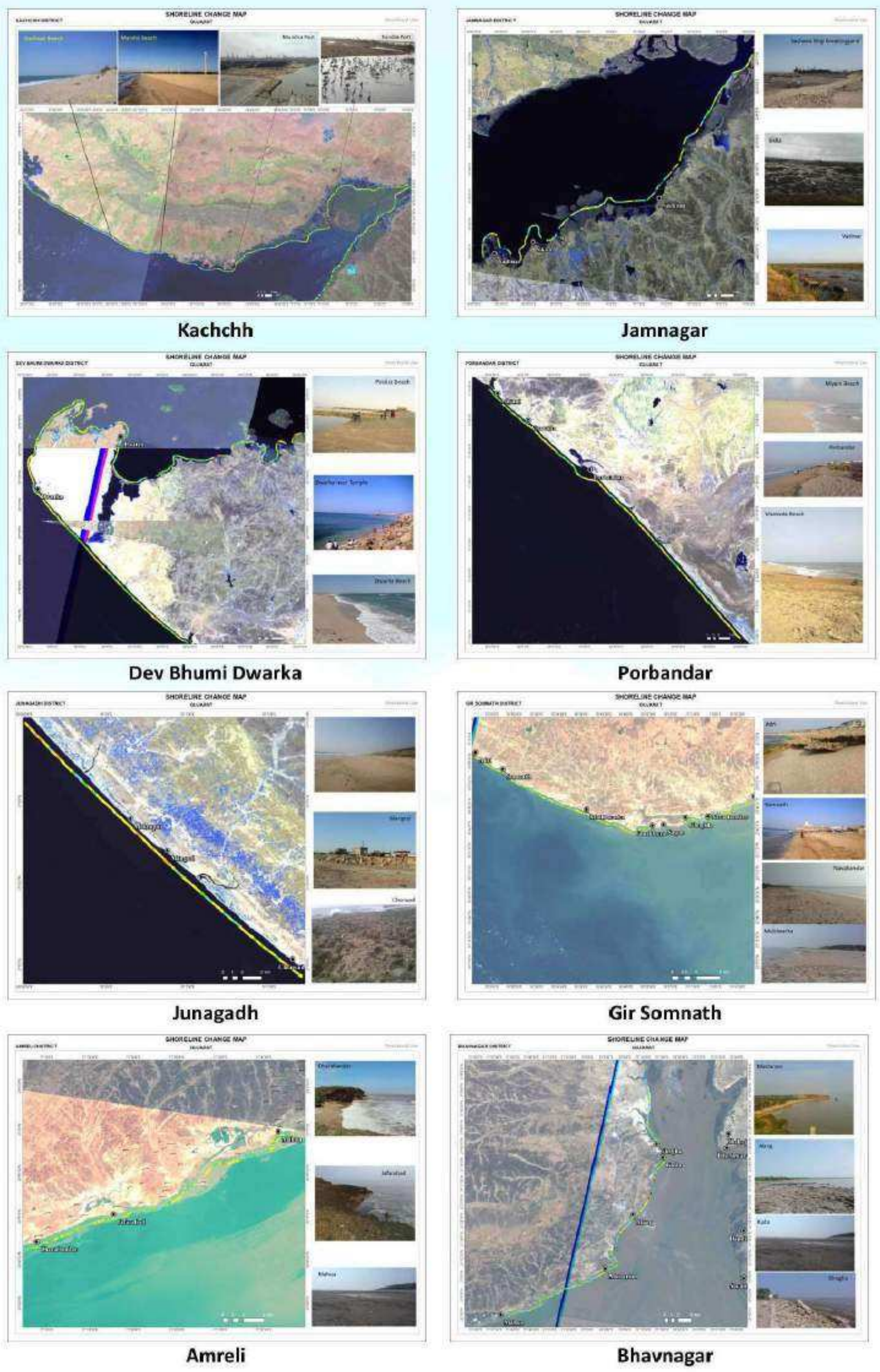


Figure 10: Shoreline change map of Gujarat coast (1990-2016).

Figure 11: Coastal districts of Gujarat



Ahmedabad

Anand

Bharuch

Surat

Navsari

Valsad

Diu

Daman

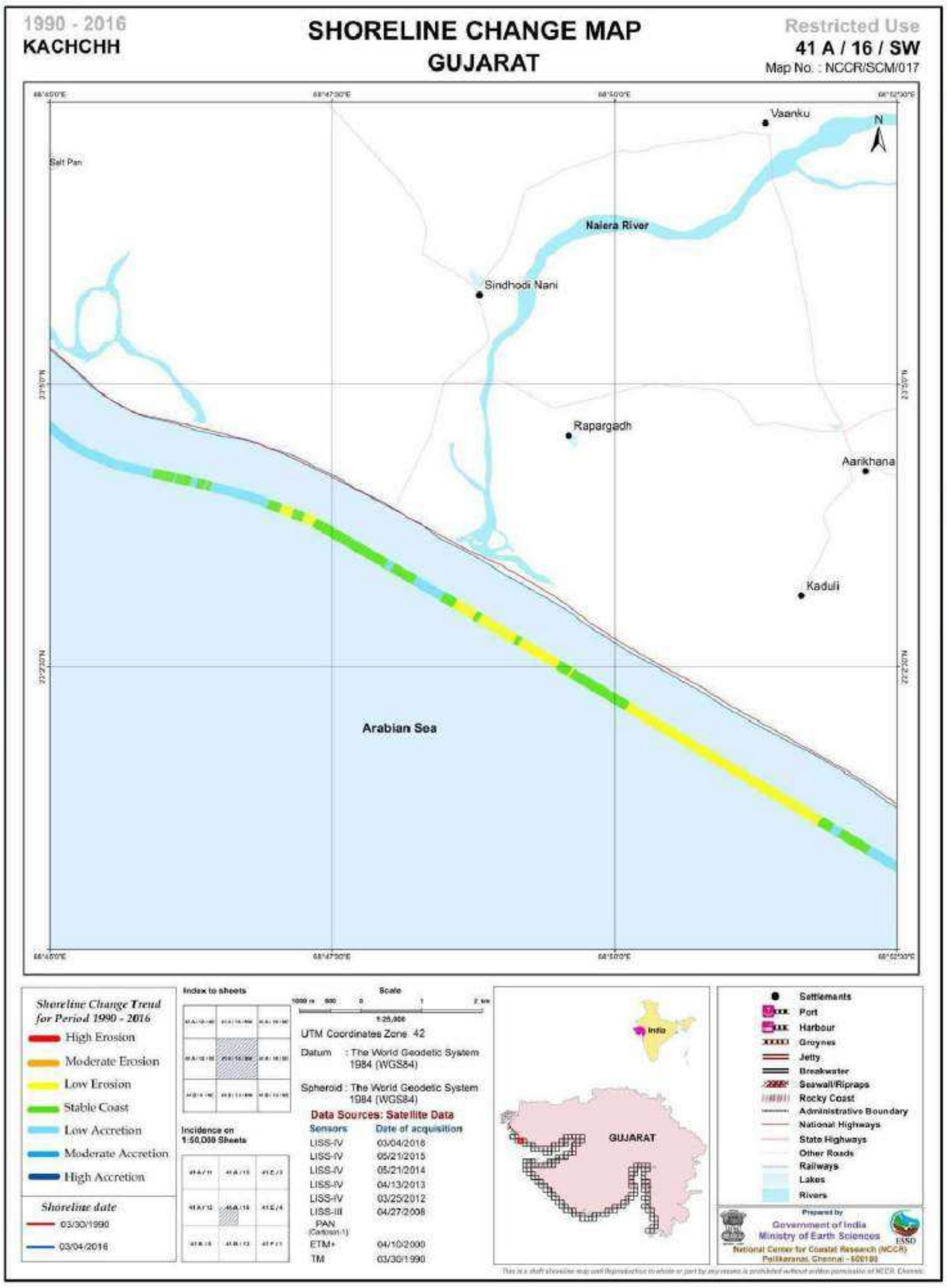


Figure 12: 1:25,000 scale map of Kachchh district, Gujarat.

4.3.2 Maharashtra

The coastline of Maharashtra is more or less N-S oriented and is bound by Arabian Sea in the west and Western Ghats in the east, with narrow coastal tract. Rivers like Terekhol, Karli, Savitri, Vashi, Shastri, Patalganga, Kundalika, Ulhas and Vaitarna and 5 major creeks are reported along the coast. The drainage pattern is parallel to sub parallel structurally controlled by joints and faults. Rocky coast, sandy shores, muddy and mangrove shore are the coastal types prevalent here with the occasional presence of patches of corals in places like Malvan. Rivers, creeks and outcrops from foot hills of Sahyadri highly dissect the coast and contribute to the diversified coastal configuration and beaches along this stretch. The coastal stretch constitutes 7 districts, viz., Sindhudurg, Ratnagiri, Raigad, Mumbai city, Mumbai suburban, Thane and Palghar.

Coastal length of the state is estimated to be approximately 740 km from 2016 satellite imagery. Shoreline change analysis carried out along the 740 km of coast from 1990-2016 elucidates that around 24% of the coast is eroding, 12% is accreting and 64% remains in stable condition. It is seen that Sindhudurg, Ratnagiri and Raigad districts of the state is dominated by stable coast with a few pockets of low erosion and accretion. Upon moving north of Thane creek, from Mumbai to northern end of the state in Thane district, erosion is evident. Coastal protection measures taken in the form of ripraps, seawall etc., can be observed along the districts of Palghar, Thane and Mumbai.

Accretion is observed along Malvan, Tarkarli, Gad River, Girye, Devgad, Undi, Ambolagad, Velas, Revadanda, Alibag, Akshi and Aksa regions. Above mentioned places are seen to accrete naturally. Artificial land reclamation of 20.23 ha is observed north of Mahim bay in Mumbai. Rocky coast of the state constitutes to about 331.08 km, which remains in stable condition. Coast of Shiroda and Anjarle are also found to exhibit stable condition. Beach in Arvai, Vengurla, Mirya, Velshwar, Dabhol, Murud, Shrivarshan, Diveaga, Kihim, Erangal, Manori, Gorai, Bordi, Kelva&Shrigaon are observed with erosion.

Table 10: Erosion-stable-accretion status of Maharashtra coastal districts

SL No	District	Coast Length (in km)	Coast length (in km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	Sindhudurg	137.02	0.04	0.20	6.50	82.00	46.88	1.02	0.38
2	Ratnagiri	258.93	0.78	1.08	36.32	203.39	15.80	0.82	0.74
3	Raigad	134.83	0.58	2.90	42.98	81.73	5.16	0.70	0.78
4	Mumbai city	41.02	0.00	0.00	1.34	38.36	1.32	0.00	0.00
5	Mumbai suburban	41.15	0.02	0.22	17.54	18.77	2.78	0.58	1.24
6	Palghar &Thane	126.64	1.12	4.98	61.66	48.44	6.28	2.26	1.90
TOTAL		**739.57**	**2.54**	**9.38**	**166.34**	**472.67**	**78.22**	**5.38**	**5.04**

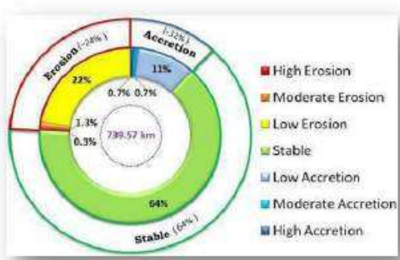


Figure 13: Percentage of shoreline change rate along Maharashtra coast.

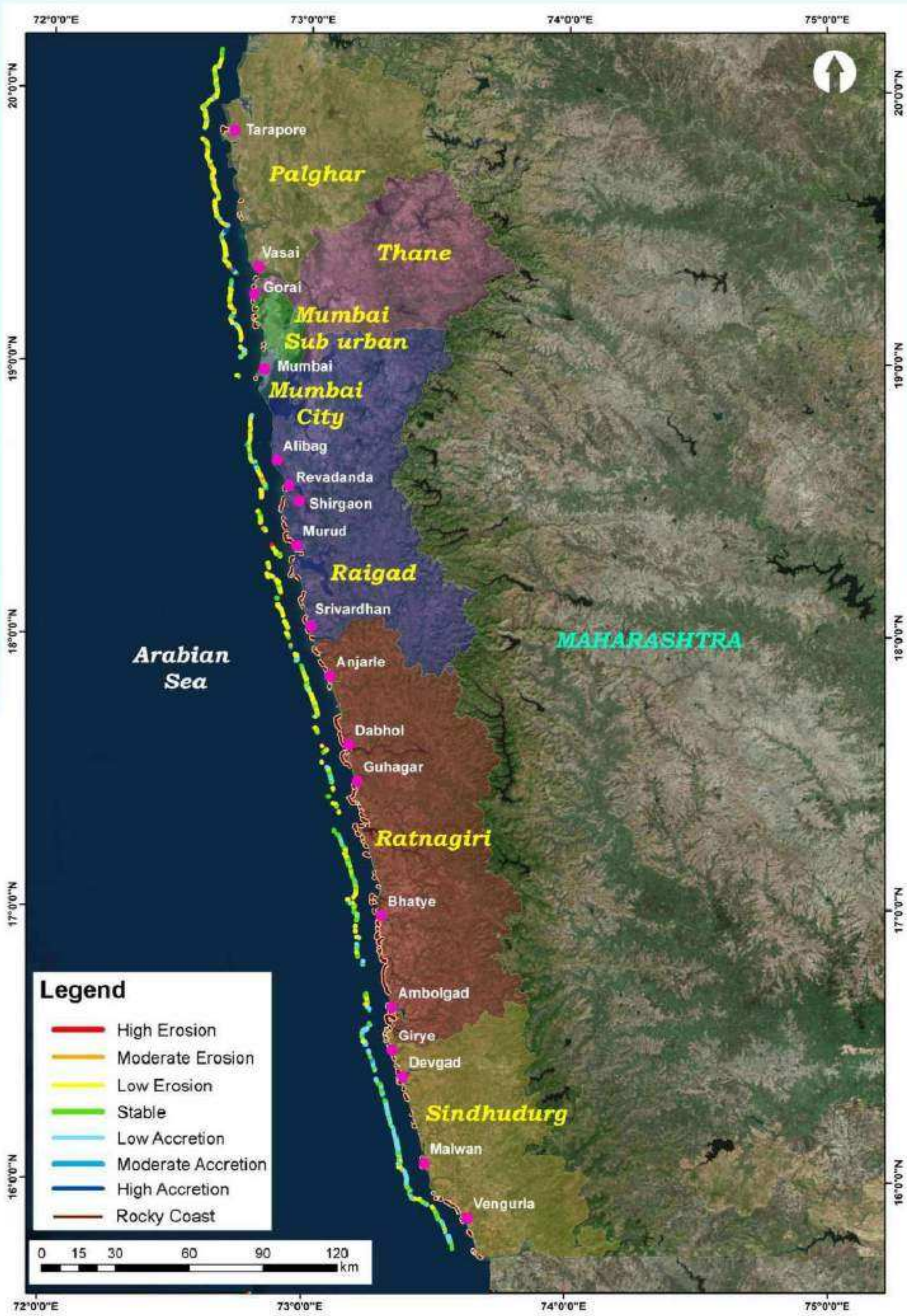
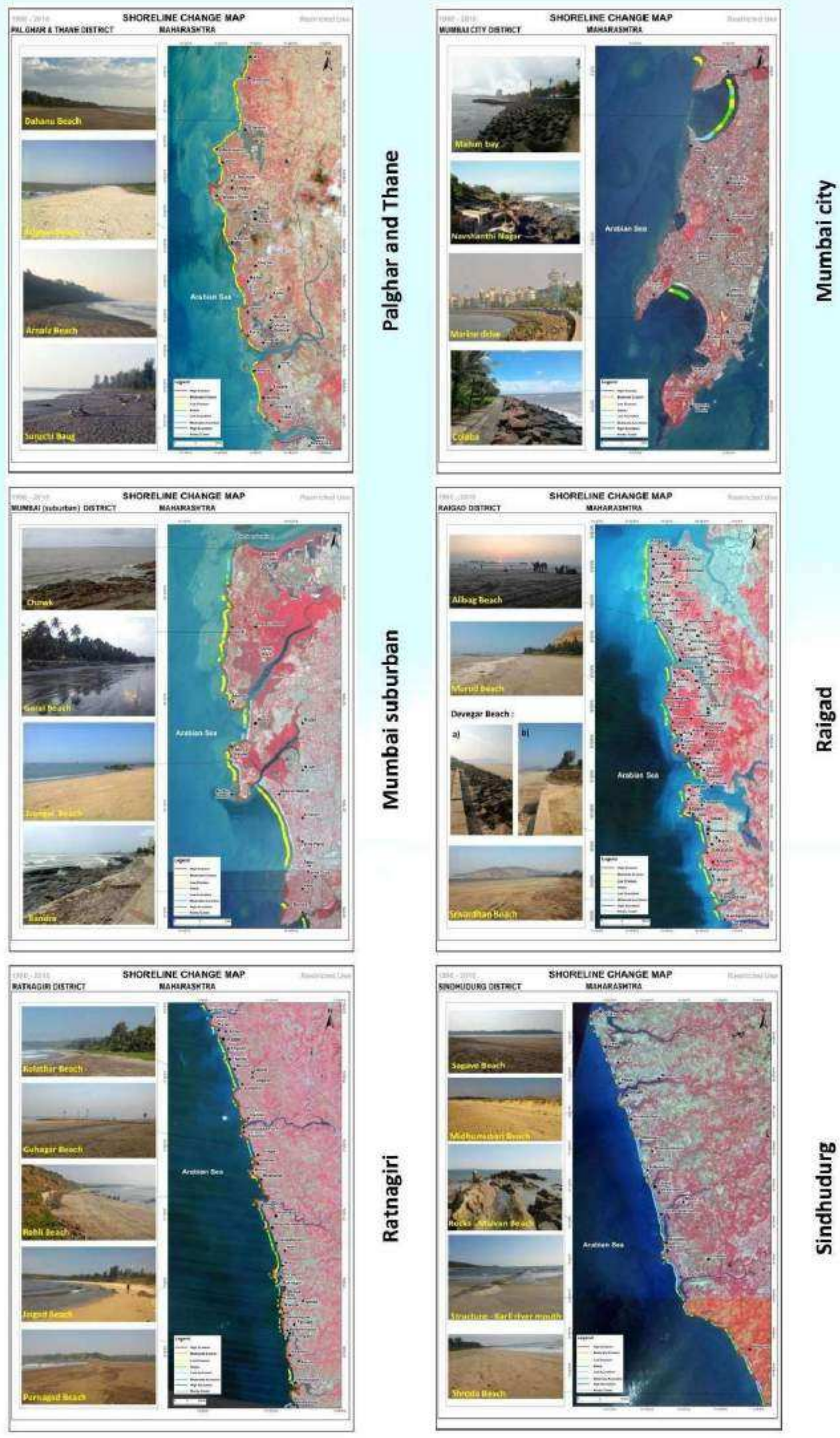


Figure 14: Shoreline change map of Maharashtra coast (1990-2016).

Figure 15: Coastal district of Maharashtra



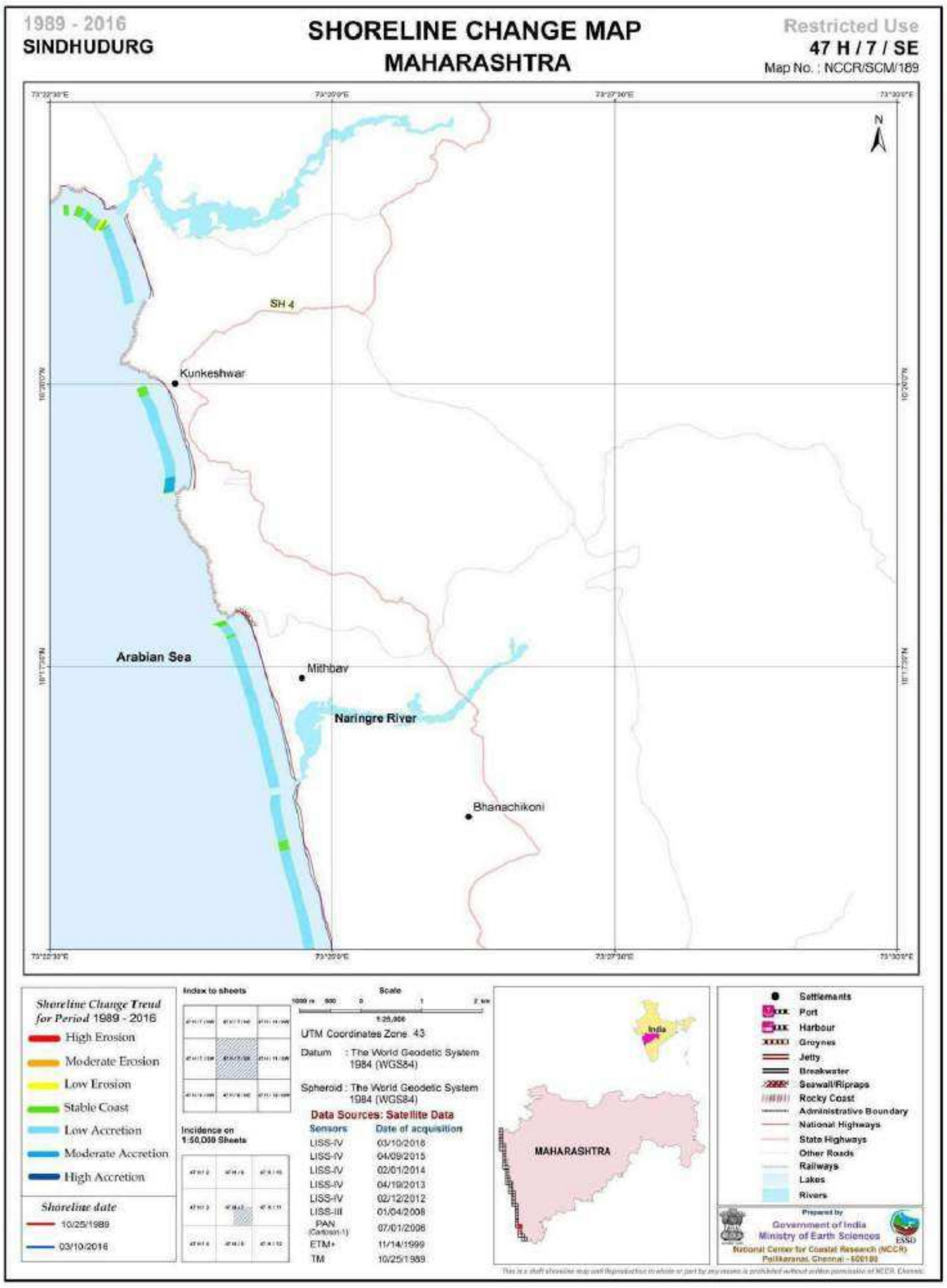


Figure 16: 1:25,000 scale map of Sindhudurgdistrict, Maharashtra.

4.3.3 Goa

Geomorphologically the coast of Goa can be divided into three sections - long, linear and wide beaches of north, central bay area around Aguada & Mormagao and rocky cliff with pocket beaches of south. Zuari, Mandovi, Chapora, Talpona and Galgibag are a few of the important rivers flowing through the state. These rivers drain into Arabian Sea forming estuary at their mouth region. About 12 species of mangroves are found along the estuaries in the state. Morjim beach found north of Chaporariver is nesting site of endangered olive ridley sea turtles. Picturesque beaches along the coast attract international tourists and promote economy of the coastal belt through tourism. Port in Mormagao bay of the state is one of the biggest natural ports of south Asia.

Coast length of Goa is about 140 km as measured from 2016 satellite imagery. Shoreline analysis of the state from 1990 - 2016 shows that around 68% of the coast is in stable condition, 20% is accreting and 12% is eroding. The coast of North Goa district is stable with a few pockets of erosion and accretion regions. It's observed that 29% of North Goa district is eroding. South Goa is also dominated by stable coast with about 20% of the coast showing accretion. Major portion of the Goa coast which comes under stable category constitutes rocky cliff, headlands and promontories of basaltic origin which are resistant to wave action. Headlands and promontories occurring in the stretch play an important role in controlling the morphology of the beach adjacent to them. Sediments along the pocket beaches get circulated within the headland, bounding their ends depending on season.

InFigure 18, we find that accretion is observed in Majorda, Velsao, Arossim, Utorda, Colva, Morbor, Betul regions of South Goa and northern part of Calangute beach, northern bank of Chapora river and along coastal stretch from Harmal to Mandrem of North Goa. Erosion is seen in the coast of Keri, Vagotor, southern part of Calangute, Mandrem to Morjim, Candolim in North Goa and Palolem, Talpona, north of Galgibaga and region from Varca to Cavelossim in South Goa.

Table 11: Erosion-stable-accretion status of Goa coastal districts

SL No	District	Coast Length (in km)	Coast length (in km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	North Goa	36.40	0.06	1.36	9.18	19.46	6.08	0.22	0.04
2	South Goa	103.24	0.02	0.10	6.10	76.12	16.92	3.30	0.68
TOTAL		**139.64**	**0.08**	**1.46**	**15.28**	**95.58**	**23.00**	**3.52**	**0.72**

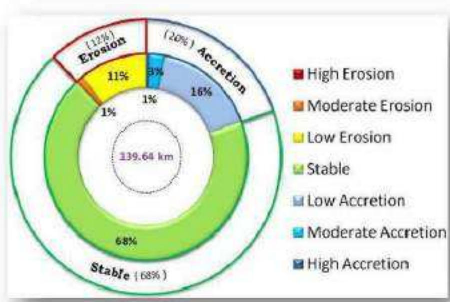


Figure 17: Percentage of shoreline change rate along Goa coast.

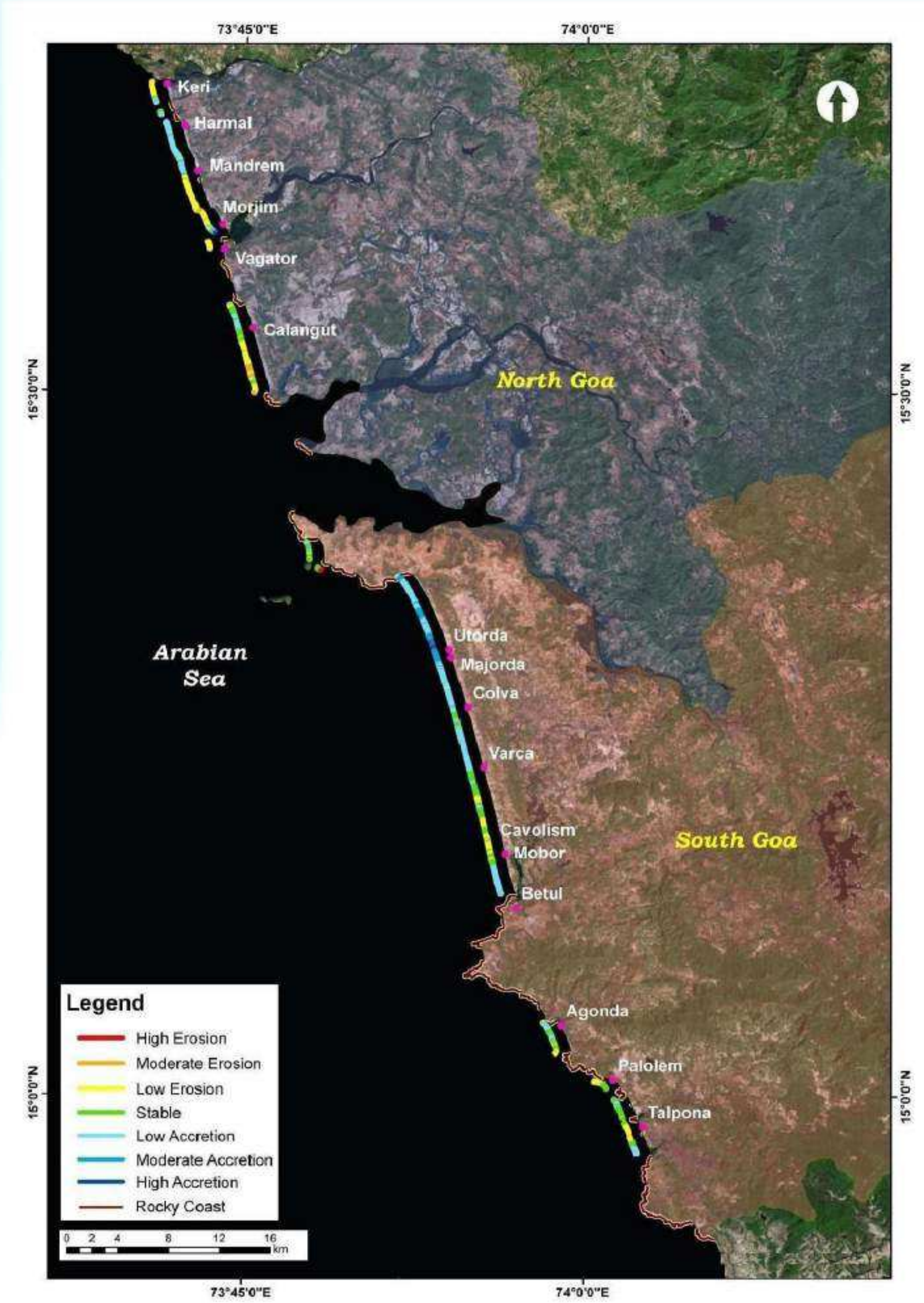
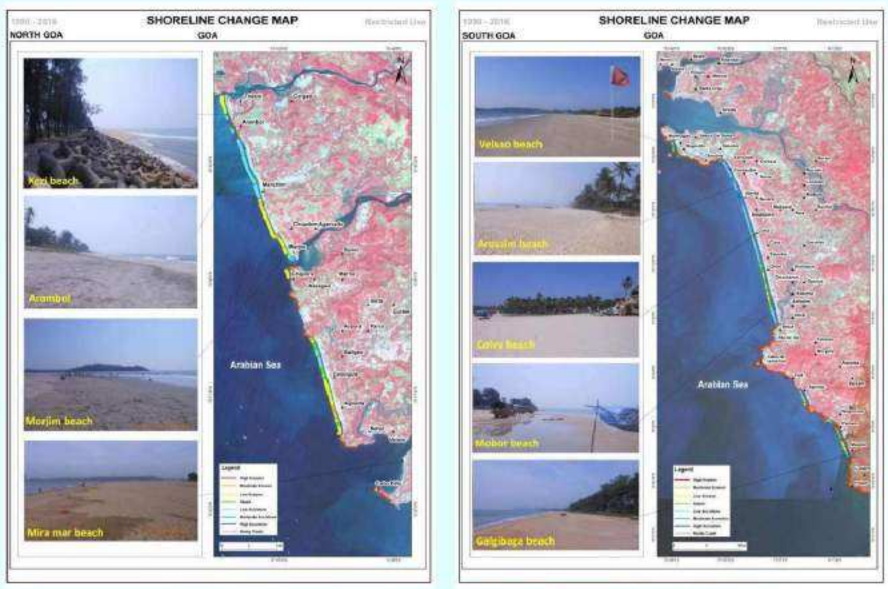
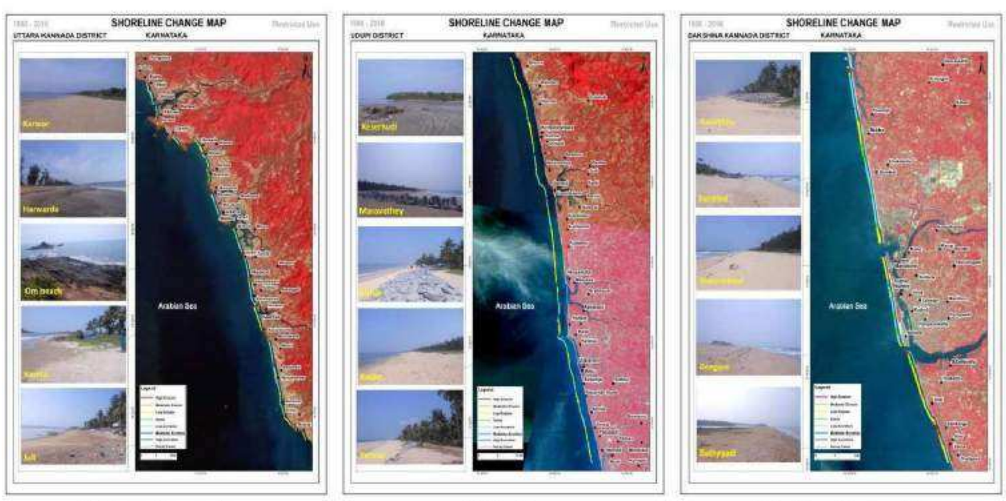


Figure 18: Shoreline change map of Goa coast (1990-2016).



North Goa South Goa

Figure 19: Coastal district of Goa



Uttara Kannada Udupi DakshinaKannada

Figure 20: Coastal district of Karnataka

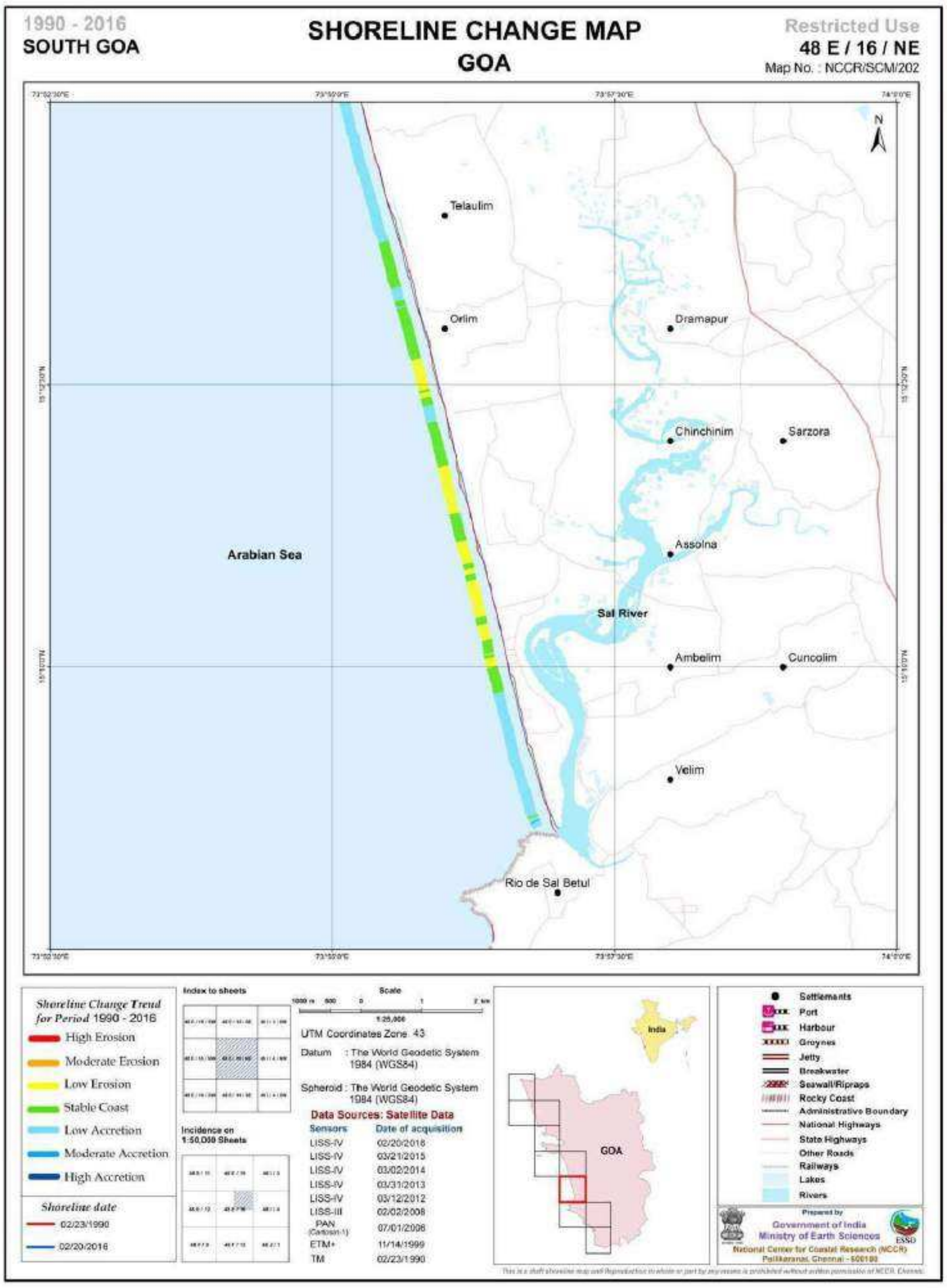


Figure 21: 1:25,000 scale map of South Goa district, Goa.

4.3.4 Karnataka

The coastal plain of the state is narrow, except at estuaries. Netravati and Sharavathi are the major west flowing rivers in the region. Rocky headlands, promontories and sea cliff are present along the northern part of the state with the prevalence of pocket beaches. Long, narrow and straight beaches are observed in the central and southern parts of the state (eg. Suratkal, Panamburu and near Coondapur). Estuaries, spit, shallow lagoons and mudflats are some of the geomorphic features found on the coast. Patches of Mangroves are present along the estuaries of Mulki, Sita, Kali, Swarna, Chakra, Haldi, Kolluru and Agnashani. Major port at New Mangalore and 10 other minor ports in Belkeri, Tadadi, Honnavar, Bhatkal, Malpe, Kundapura, Hangarakatta and Padubidricontribute to the economy of the coastal districts. Sand mining, petrochemical, fertilizer and allied industries are seen along the coast.

The coastal length of the state is about 313 km as estimated from 2016 satellite imagery. Shoreline analysis of the coast from 1990-2016 shows that 30% of the coast is accreting and 22% is eroding and 48% in stable state. It is observed that 45% of Dakshina Kannada district is relatively affected by erosion and Uttara Kannada is dominated by stable condition with a few pockets of erosion and accretion. Stable and erosion conditions are prevalent along the Udupi coast with a few sectors of accretion.

Eroding coastal stretches are Mukka, Ullal, Thalapadi, north of Thannirbavi and Bathypadi in Dakshina Kannada District and Malpe, Mulur, Yermal, Kirimanjeshwara, Hejmadi, Pithrody, Kinara, Maravathey, Koravadi and Kaipunjal regions of Udupi. Though Uttara Kannada District of the state is dominated by low accretion and stable coast, erosion is observed in Apsarakonda, Harwarda, Kasarkod and about 11 km from Keserkudi to Jali. Accretion is observed along Bengere, south of Thannirbavi and Chitrapura in the southern end of the state and along Kadke, Udyavara and Beejadi in Udupi district. Regions of Murudeshwar, Pavinakurve, Gokarna, Majali, Devbag and Karwar beaches are observed to exhibit accretion.

Table 12: Erosion-stable-accretion status of Karnataka coastal districts

SL No	District	Coast Length (in Km)	Coast length (in Km)						
			High Erosion	Moderate Erosion	Low Erosion	Stable	Low Accretion	Moderate Accretion	High Accretion
1	Dakshinna Kannada	36.66	1.08	2.36	13.18	7.72	12.08	0.22	0.02
2	Udupi	100.71	0.32	0.98	34.92	35.69	25.44	2.36	1.00
3	Uttara Kannada	175.65	0.80	1.12	15.26	107.75	44.12	5.54	1.06
TOTAL		**313.02**	**2.20**	**4.46**	**63.36**	**151.16**	**81.64**	**8.12**	**2.08**

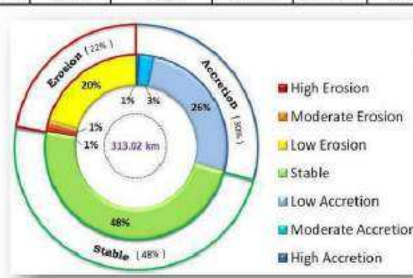


Figure 22: Percentage of shoreline change rate along Karnataka coast.

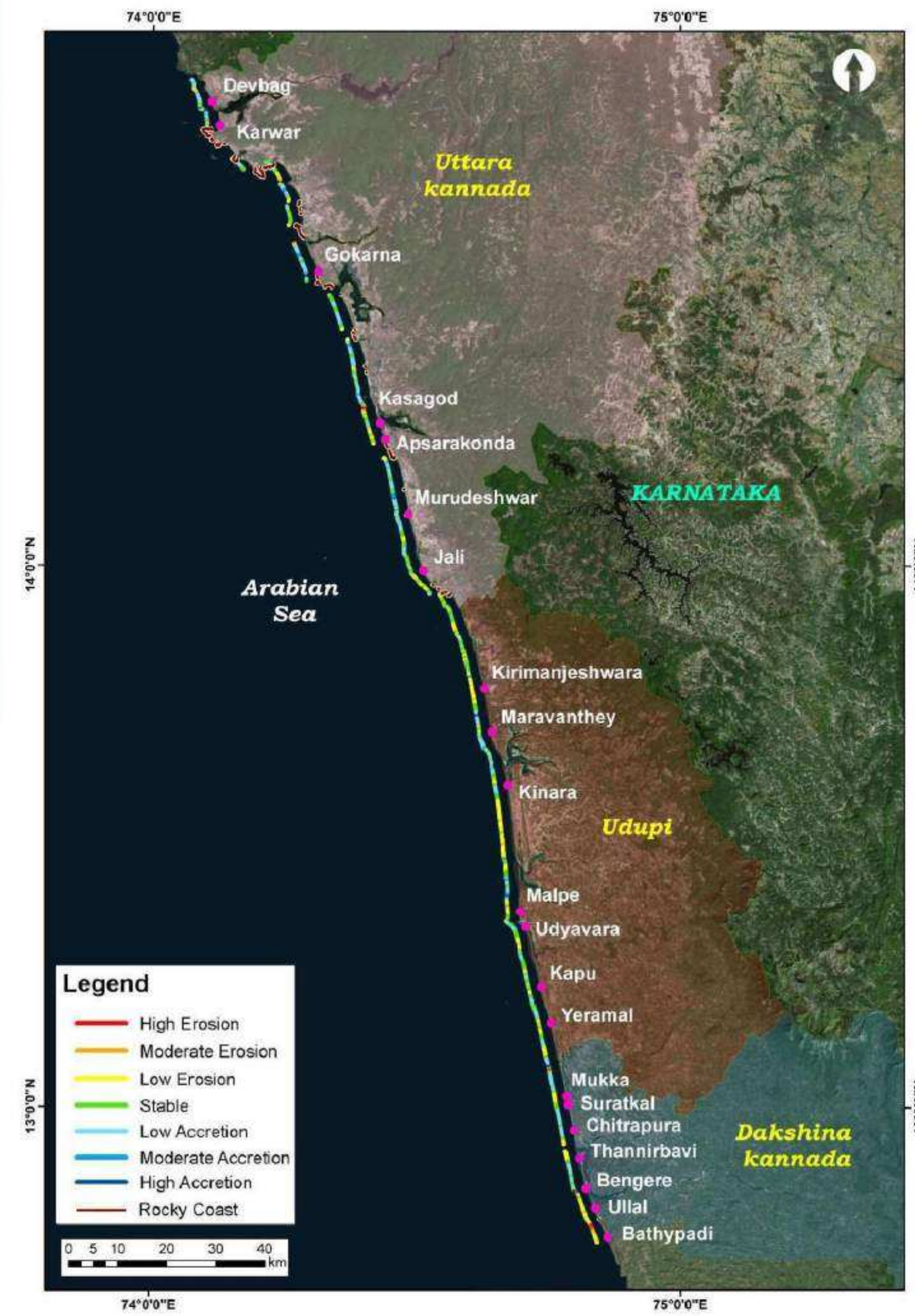
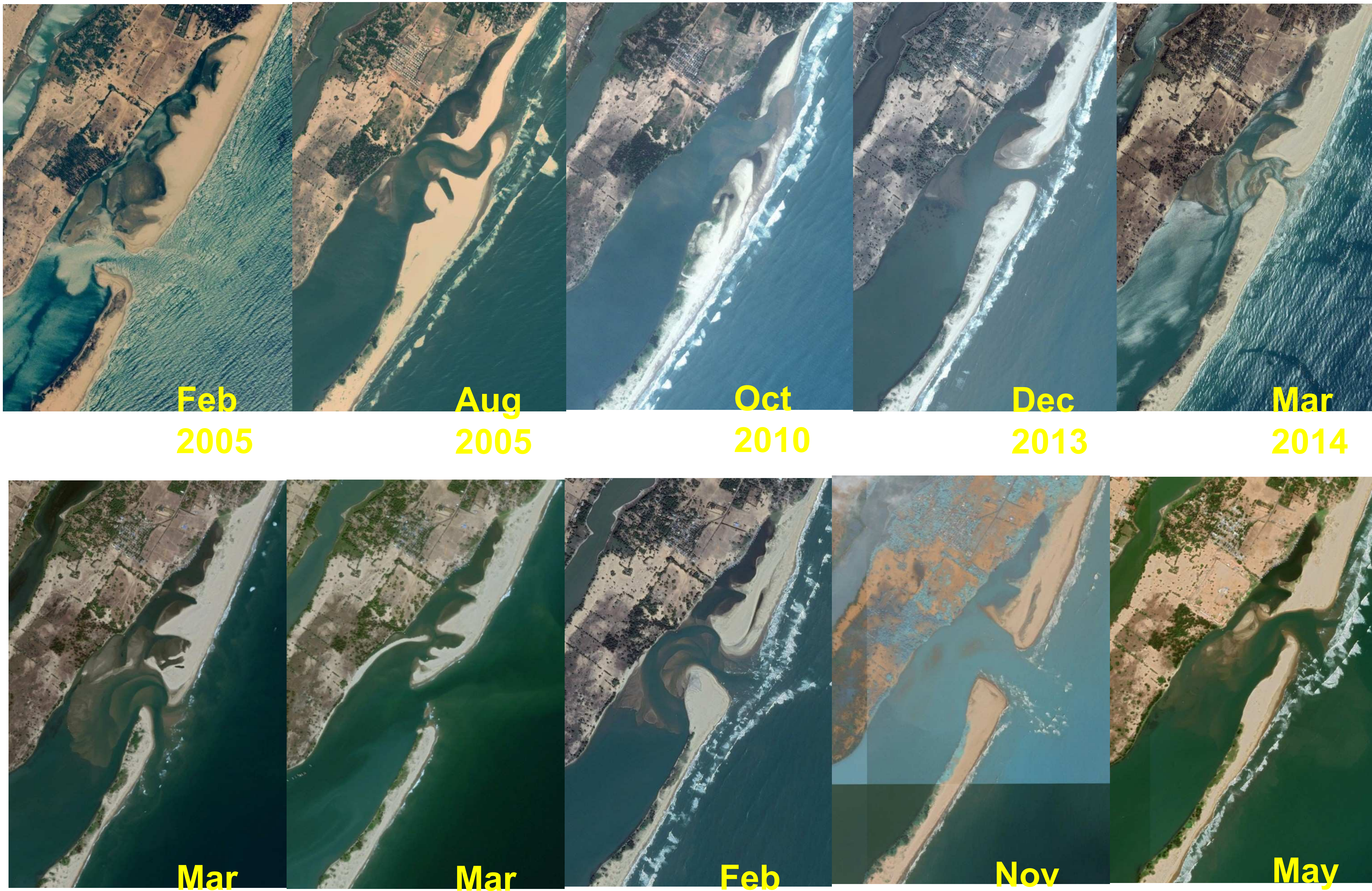


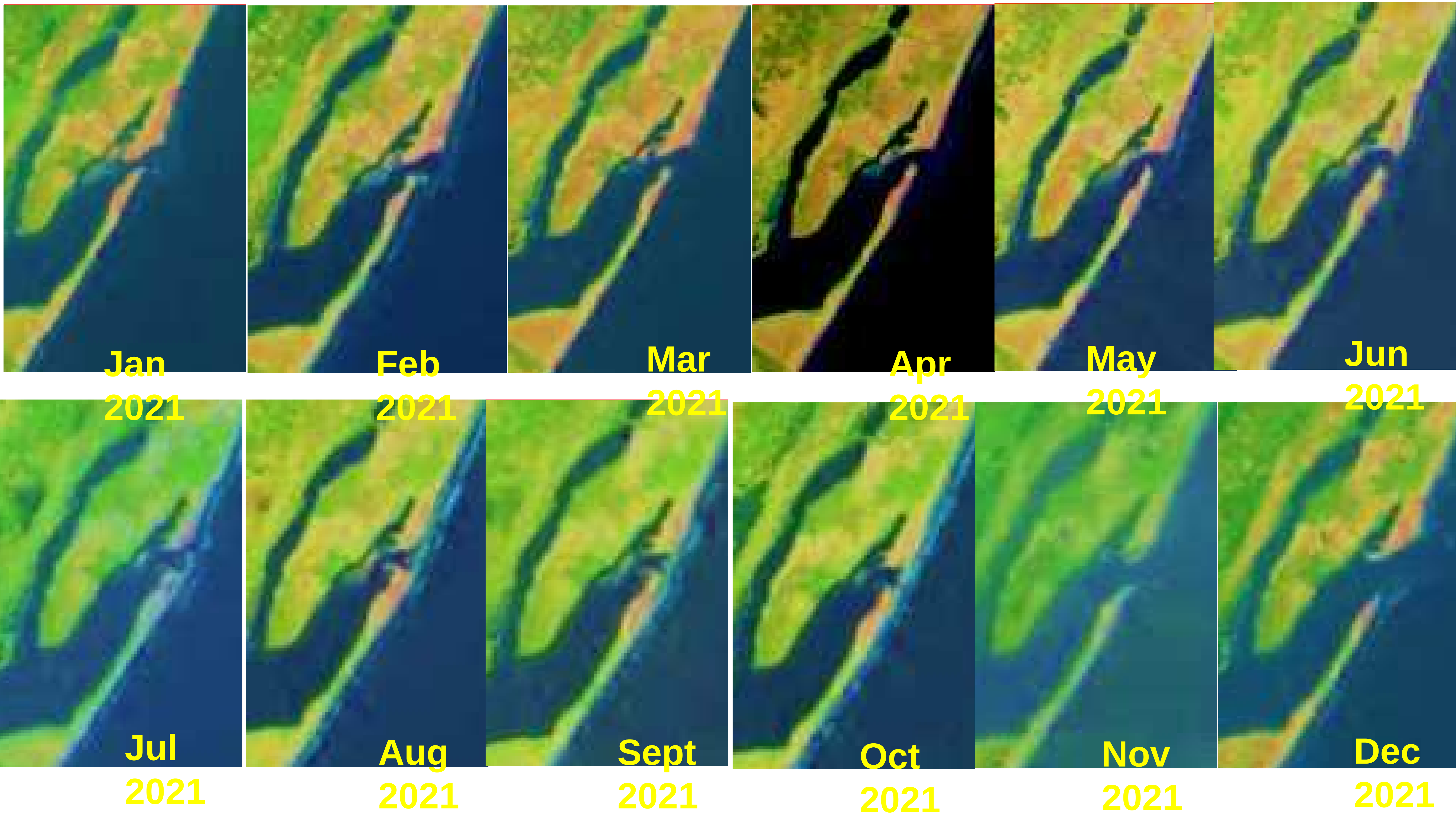
Figure 23: Shoreline change map of Karnataka coast (1990-2016).

GOOGLE MAP SHOWING THE DISTANCE BETWEEN KALUVELI BIRD SANCTUARY AND AZHAGANKUPPAM FISHING HARBOUR IS 18.10 KM

GOOGLE MAP SHOWING BARMOUTH OPENING IN DECEMBER 2021 IS ABOUT 540M AWAY FROM THE LOCATION WHERE IT OPENED IN 2005



GOOGLE MAP SHOWING THE YEARWISE SHIFTING OF KALUVELI BAR MOUTH



SATELLITE MAP SHOWING THE MONTHLY SHIFTING OF KALUVELI BAR MOUTH IN 2021