Strengthening Coastal Resilience and the Economy – Tamil Nadu(TN-SHORE) (with financial support from the World Bank)

Environment and Social Impact Assessment and Environment and Social Management Plan

for

"Enhancing the Coastal Community's Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar, Tamil Nadu"

Client

Wildlife Warden
Wildlife Division, Ramanathapuram
Tamil Nadu Forest Department
For Tamil Nadu Green Climate Company

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Table of Contents

List of Figures

List of Tables

List of Annexures

List of Abbreviations

ACB	:	Acropora Branching
ACD	:	Acropora Digitate
ACE	:	Acropora Encrusting
ACF	:	Acropora Foliose
AR	:	Artificial Reef
BBQ	:	Bill of Quantities
BOD	:	Biological Oxygen Demand
CB	:	Coral Branching
CBD	:	Convention on Biological Diversity
CCA	:	Crustose Coralline Algae
CE	:	Coral Encrusting
CF	:	Coral Foliose
CM	:	Coral Massive
COD	:	Chemical Oxygen Demand
CR	:	Coral Reef
CS	:	Coral Submassive
DFO	:	District Forest Officer
DGPS	:	Differential Global Positioning System
DO	:	Dissolved Oxygen
ESF	:	Environmental and Social Framework
ESIA	:	Environmental and Social Impact Assessment
ESMP	:	Environment and Social Management Plan
ESS		Environmental and Social Standards
GBV	:	Gender-Based Violence
GOI	:	Government of India
GOM	:	Gulf of Mannar
GOMBR	:	Gulf of Mannar Biosphere Reserve
GOMMNP	:	Gulf of Mannar Marine National Park
IIT	:	Indian Institute of Technology
LMP	:	Labor Management Procedure
LIT	:	Line Intercept Transect
NAFCC	:	National Adaptation Fund for Climate Change
NTU	:	Nephelometric Turbidity Unit
OHS	:	Occupational Health and Safety
OSHA	:	Occupational Safety and Health Administration
PCR	:	Patch Coral Reef
PPB	:	Parts Per Billion
PPE	:	Personal Protective Equipment
PPT	:	Parts Per Thousand
SAPCC	:	State Action Plan on Climate Change
SD	:	Sedimentation
SDG	:	Sustainable Development Goal
SHG	:	Self Help Group
SPMU	:	State Project Management Unit
SR	:	Sea Grass
TC	:	Total Coliform Bacteria

TNGCC	:	Tamil Nadu Green Climate Company
TSS	:	Total suspended solids

Executive summary

The Tamil Nadu - Strengthening Coastal Resilience and the Economy project (P180932) is designed to fortify the resilience and sustainable use of coastal resources through a comprehensive, multi-faceted approach. It aims for a holistic integration across various sectors to foster a resilient and circular blue economy, empower local livelihood, and build capacities for a more sustainable future. The project is structured around five strategically prioritized thematic investment areas, each addressing key components of coastal resource management. It has components such as strengthening institutions for integrated coastal zone management; shoreline management, coastal protection, and conservation; improving livelihoods for natural resource dependent communities; enhancing plastic circularity and marine pollution management; and developing a contingent emergency response component.

This Environment and Social Impact Assessment (ESIA) and Environment and Social Management Plan (ESMP) deals with the sub-project titled “Enhancing the Coastal Community’s Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar, Tamil Nadu”. Kariyachalli Island is one of the 21 islands of the Gulf of Mannar on the southeast coast of India off the coast of Tamil Nadu. Kariyachalli Island is about 4 km south of Sippikulam and about 20 km northeast of the Tuticorin Old Harbour. The total area of the island was 20.85 hectares in 1969 and 16.46 hectares in 1986 during the Marine National Park Notification but it shrunk to 9.71 hectares in 2017. In the past, mining of corals by human and climate change effects like coral bleaching have led to large scale degradation of corals. This has affected the dependent fishing communities. The loss of coral reefs which act as first line defence line caused erosion and reduced the island area over time. Hence, climate change adaptation practices are needed (i) to protect this Island from submergence, (ii) to restore the degraded coastal habitats like coral reefs and seagrass beds and (iii) to make the coastal communities resilient to and withstand the vagaries of climate change.

The sub-project's Kariyachalli Island restoration initiative is structured around a series of carefully planned interventions and activities, aimed at restoring the submerging Island and sustaining the ecological and economic benefits for a long-term use. The objectives of the sub-project are (i) Deployment of multipurpose artificial reef modules in Kariyachalli Island in order to protect and restore this eroding island and to enhance the coral-associated biodiversity in particular fish production to help build livelihood sustainability for the benefit of small-scale fishers through incremental fish production, and to maintain ecological balance, (ii) Restoration of the ecological services through rehabilitation of degraded coral reefs and seagrasses around Kariyachalli Islands as options for climate adaptation and provision of stable substratum to protect Kariyachalli Island, and (iii) Promotion of eco-development activities among the coastal communities to enhance their adaptive capacity so that they can have sustained livelihood and food security.

In this report, the prevailing key National and State level laws, rules, policies, Acts, notifications pertaining to environmental, climate change and social aspects have been reviewed for their applicability to the proposed activities of the sub-project and the relevance of Environmental and Social Standards (ESS) applicable for this sub-project have also been detailed. The sub-project activities have been found to be relevant to several existing Acts, rules, laws and policies. Moreover, these activities are relevant to ESS 1, ESS 2, ESS 3, ESS 4, ESS 6 and ESS 10. Further, the sub-project also addresses many parts of the UN’s SDG 14. The sub-project is also clearly a climate change adaptation initiative and is aligned with climate change requirements under Coastal Ecosystem Restoration under Tamil Nadu Coastal Mission, SAPCC and NAFCC activities.

The baseline data required to understand the environmental, ecological attributes and socio-economic characteristics of the study area were collected. The parameters for the baseline data include climate, meteorology, rainfall, soil, flora, fauna and social profile of local population. The objective is to comprehend the current environmental conditions and socio-economic status of people, which would help in comparing and assessing the impacts on E&S aspects caused by the sub-project in the construction and operation stages. Physical, chemical and other environmental parameters at the sub-project site align with the limits optimum for a tropical environment. Biodiversity was studied around the proposed sub-project site within a 5 km radius, which also covered the nearby Vilanguchalli Island. A total of 8 major coral reef sites and 9 patch reef sites were identified and assessed. Out of the 8 major coral sites, 4 fall around Kariyachalli Island and 4 around Vilanguchalli Island. Patch reefs occur scattered within the 5 km radius of the sub-project site, and 4 of them fall closer to Kariyachalli Island and 5 closer to Vilanguchalli Island. Likewise, 17 seagrass sites were also identified within the 5 km radius of the sub-project site, and of which 11 fall closer to Kariyachalli Island and 6 closer to Vilanguchalli Island.

Within the 10 km radius of Kariyachalli Island, there are three fishing villages namely Vaipar, Sippikulam and Pattinamaruthoor. Sippikulam is about 3.5 km away from the Island. Vaipar and Pattinamaruthoor are about 4 and 8 km respectively away from the Island. The present study included more villages that may be benefitted from the sub-project activities as the fishermen in these villages (totally 10 villages) have long fishing connections with the sub-project area. Majority of the fishermen of these villages depend on traditional fishing. They use motorized and non-motorized fishing boats for their livelihood. Altogether 8,698 fisher families with a total population of 33,143 live along the coast in these ten villages and almost 98% of fisher families in these villages are Below Poverty Line (BPL). Most of the area within the 10 km radius of the sub-project site falls within the boundary of the Gulf of Mannar Marine National Park (GOMMNP), where commercial fishing is not allowed particularly in places 1 km around the Islands. However, there are fishing grounds that fall outside the boundary of the GOMMNP and within the 10 km radius. The fishermen do fishing in places about 1 km away from the coral reef, seagrass and sandy areas near the sub-project site and the total number of legitimate fishing grounds within the 10 km radius of the sub-project site is 22. An additional 10 fishing grounds are found in the route of the barge transportation from Tuticorin Old Harbour. A total of 375 fishing crafts are being operated within the 10 km radius of the sub-project site and a total of 1,156 fishermen are involved in fishing here.

Potential environmental benefits of the sub-project include the improvement in the biological characteristics of the reefs on site/surrounding seabed and the faunal communities; the diversion of subsistence or commercial fishing pressure away from sensitive natural ecosystems; protection of vulnerable ecosystems from destructive/illegal fishing techniques; reduction of some of the impacts and improvement of water quality; compensation for habitat loss; and re-establishment of biological communities. Similarly, potential socio-economic benefits include increased marine/fisheries resources availability leading to improved food security and standard of living for local people; enhancement and/or protection of local/coastal fisheries; improved fishing conditions for local fishermen; improvements in recreational opportunities; enhancement of stocks through habitat creation; new or enhanced opportunities for aquaculture developments; enhanced supply of fisheries resources; and research and educational opportunities.

Rows of AR modules (20 m width and 850 m length) will be placed continuously along the 3 to 4 m contour at the southeast of the Island. The design of AR modules and the location of deployment had been decided after performing wave modelling studies. Due to the activities of the sub-project, land-based impacts, impact on water quality, impact on noise quality,

impact on marine traffic and navigation, impact on coral reefs, impact on seagrasses, impact on fishery resources, impact on fishing activities, impact on benthic organisms and impact due to loading and unloading of artificial reef modules have been thoroughly analysed. And the proposed activities were also evaluated with ESS in terms of risks and impacts. It has been concluded that the sub-project has a holistic approach that strengthens the environment thereby providing long-lasting benefits to the society. The sub-project activities will enhance the adaptive capacity of the coastal community so that they can have sustained livelihood and food security.

The stakeholder consultation was conducted in accordance with the principles of transparency, inclusivity, and responsiveness. The implementing agency ensured that the stakeholders were informed about the sub-project's objectives, activities, and potential impacts, and that their input was given due consideration. Regular updates will be provided to stakeholders to keep them informed of the sub-project's progress and the changes, if any, to its implementing. The implementing agency is committed to promoting meaningful engagement with all stakeholders to achieve the best outcomes for the sub-project and the communities it impacts.

The ESMP has been developed, based on the impact assessment to provide mitigation measures to reduce the negative impacts to acceptable levels. Three ESMPs have been prepared for various sub-project activities viz. (i) Deployment of multipurpose artificial reef modules, (ii) Coral Rehabilitation, and (iii) Seagrass Rehabilitation. The ESMP includes a monitoring program to measure the environmental condition and effectiveness of implementation of the mitigation measures. It will include observations on- and off-site, document checks, and interviews with workers and beneficiaries. The ESMPs will be included in the bid and contract documents to ensure compliance to the conditions set out in this document. Systematic monitoring would help to ensure the success of the sub-project, understand the status of environmental health during the construction and deployment period and accordingly the management and remedial action could be taken up. Constant monitoring of island morphology, bathymetry, environmental parameters, benthic habitats, fish assemblage and fishery resources will be in place to take effective management and remedial actions in the face of any adverse impacts. The environmental monitoring report for submission to the World Bank will be on a quarterly basis during construction and on a semi-annual basis during operation. A Grievance Redress Mechanism has been proposed that allows not only grievance redress, but also queries, suggestions, positive feedback, and concerns of project-affected parties related to the environmental and social performance of a sub-project.

The project will be implemented as the ‘Tamil Nadu Coastal Restoration Mission’ by the State Project Management Unit (SPMU) housed in the Tamil Nadu Green Climate Company (TNGCC) under the Department of Environment, Climate Change and Forests, Government of Tamil Nadu. The SPMU will be headed by a Project Director, comprising department officials and supported by PMC for implementation of technical, financial, procurement, environmental and social safeguards aspects. A High-Powered Steering Committee (HPSC) chaired by the Chief Secretary and including all relevant senior officials has been established for oversight and guidance to steer convergence, regional integration, and coordinated actions. The HPSC will be chaired by the Chief Secretary and includes the Additional Chief Secretaries / Principal Secretaries of all participating line departments. Such vertical alignment and oversight and guidance from HPSC will ensure efficient and effective project delivery, facilitate interdepartmental coordination, and pave the way for convergence.

Eco-development activities will be executed through the Gulf of Mannar Biosphere Reserve Trust under supervision of Wildlife Warden, Ramanathapuram.

The sub project “Enhancing the Coastal Community’s Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar, Tamil Nadu”.will be implanted by the Wildlife Warden, Ramanathapuram under supervision of the CCF & FD, SMTR and PCCF & CWLW, Tamil Nadu Forest Department.

1. Introduction and Background

1.1 Project background

The Tamil Nadu - Strengthening Coastal Resilience and the Economy project (P180932) is designed to fortify the resilience and sustainable use of coastal resources through a comprehensive, multi-faceted approach. It aims for a holistic integration across various sectors to foster a resilient and circular blue economy, empower local livelihood, and build capacities for a more sustainable future. The project is structured around five strategically prioritized thematic investment areas, each addressing key components of coastal resource management. the project components are given in **Table 1**.

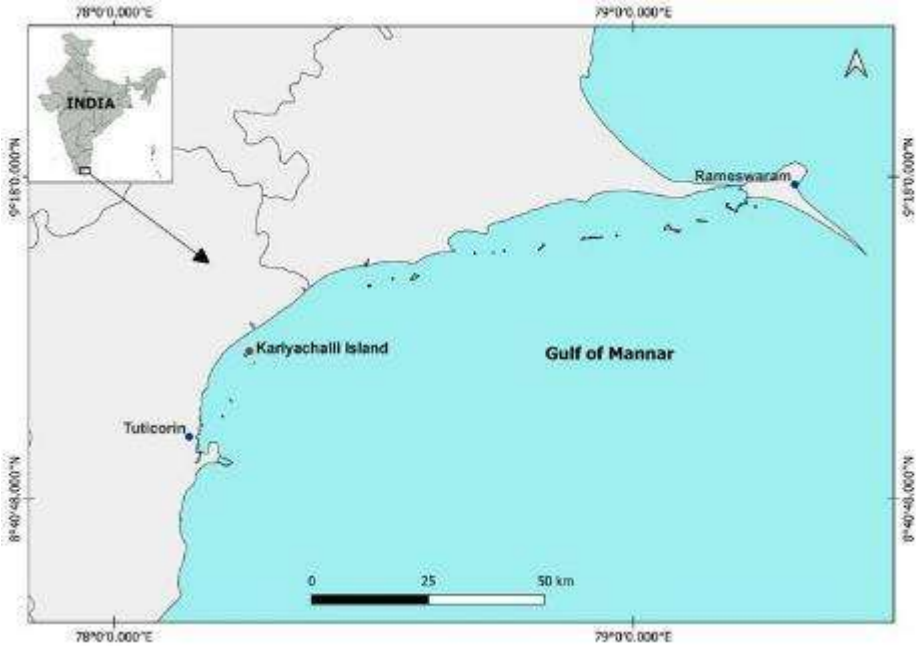
Table 1: TN-SHORE Project Components

Component 1: Strengthening Institutions for Integrated Coastal Zone Management	The development impact will be achieved through a long-term engagement in effective governance and management of coastal resources and supporting institutional frameworks for coastal resilience. A whole-of-government approach is promoted as a means for effective sectoral coordination.z
Component 2: Shoreline management, coastal protection, and conservation	The development impact will be achieved by scaling up investments for coastal protection through NBSs and enhancing the ecological sustainability of natural assets.
Component 3: Improving Livelihoods for Natural Resource Dependent Communities	The development impact will be achieved through interventions supporting livelihoods and community incomes, promoting innovation, community entrepreneurship, and private sector involvement in the sustainable use of coastal natural resources.
Component 4: Enhancing plastic circularity and marine pollution management.	The development impact will be achieved through measures for reducing ocean-bound plastic and marine pollution leakage; supporting financially viable circularity solutions; and integrating the local and fishing communities, nongovernmental organizations (NGOs), and private sector in more effective plastic waste management in coastal areas.
Component 5: Contingent Emergency Response Component (CERC).	This component will be triggered in case of a natural/manmade disaster, on the request of the client

There are several sub-projects under the components 1 to 4 of TN-SHORE project. Underthe component 2 on Shoreline management, coastal protection and conservation, one of the sub-projects is Enhancing the Coastal Community's Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar, Tamil Nadu. The sub-project aims to perform activities to control the erosion which is threatening the existence of the Island and also to restore the lost coral reef and seagrass habitats. The project is implemented by the Wild Life Warden, Ramanathapuram of Tamil Nadu Forest Department. The sub-project will be supervised by the Tamil Nadu Green Climate Company (TNGCC) which is the State Project Management Unit (SPMU)

1.2 Sub-Project Area

Kariyachalli Island is about 4 km south of Sippikulam and about 20 km northeast of theTuticorin Old Harbour (Figure 1). The total area of the island was 20.85 hectares in 1969 (Survey of India Toposheet), 16.46 hectares in 1986 during the Marine National Park Notification. It is elongated in shape with an average elevation of 0.9 m above the mean sea level. This island possesses geomorphic features such as beaches, spit, sand dunes, sandy plains and strandlines. The shape of the island is elongated in nature and the average elevation of the island is 0.9 m above the mean sea level Topography around the Island reveals that the southern side of the island is more elevated (around 1 m) than the northern side due to the presence of paleo-reef. Due to the gentle and shallower bathymetry, Kariyachalli Island is rich in biodiversity including coral reefs, seagrass beds and associated flora and fauna, which help the livelihood of the dependent artisanal fisher folk, apart from acting as a natural barrier.



Source map; Survey of India - https://onlinemaps.surveyofindia.gov.in/

Figure 1: Map showing Gulf of Mannar (GoM) region with Kariyachalli Island

Source map; Survey of India - https://onlinemaps.surveyofindia.gov.in/FreeMapSpecification.aspx

Note: The map presented in the diagram is drawn from the combination of different toposheets with serial numbers 58L/1, L/2, L/3, 58K/8, K/12, K/14, K/15, K/16, 58O/3, O/4, O/7, O/8

1.3 Existing status of Kariyachalli Island

Climate change has become the most significant threat to coastal areas, posing serious harm to both the coastal ecosystem as well as coastal communities of the mainland. It is projected that on the east coast, the surface annual air temperature is set to rise by 1.6°C to 2.1°C (28.7±0.6°C to 29.3±0.7°C). As per the secondary data, the uninhabited Kariyachalli Island has a land mass shrunk by 71.37%, from 20.85 ha to 5.97 ha and it is expected to get submerged by 2036. The data also reveals that the average coral bleaching prevalence was 34.70% for Kariyachalli Island. Degradation and disappearance of coral reefs would make the Island further vulnerable for erosion. Comparison of the area of the Island using Sentinel satellite images between 2017 and 2024 (latest available year) revealed that the area of the Island is further reduced from 9.71 ha (2017) to about 7.33 ha indicating a continued reduction in size of the Island caused by erosion leading net loss of 2.41 ha (eroded minus accreted area) in a period of 7 years (Fig 2).

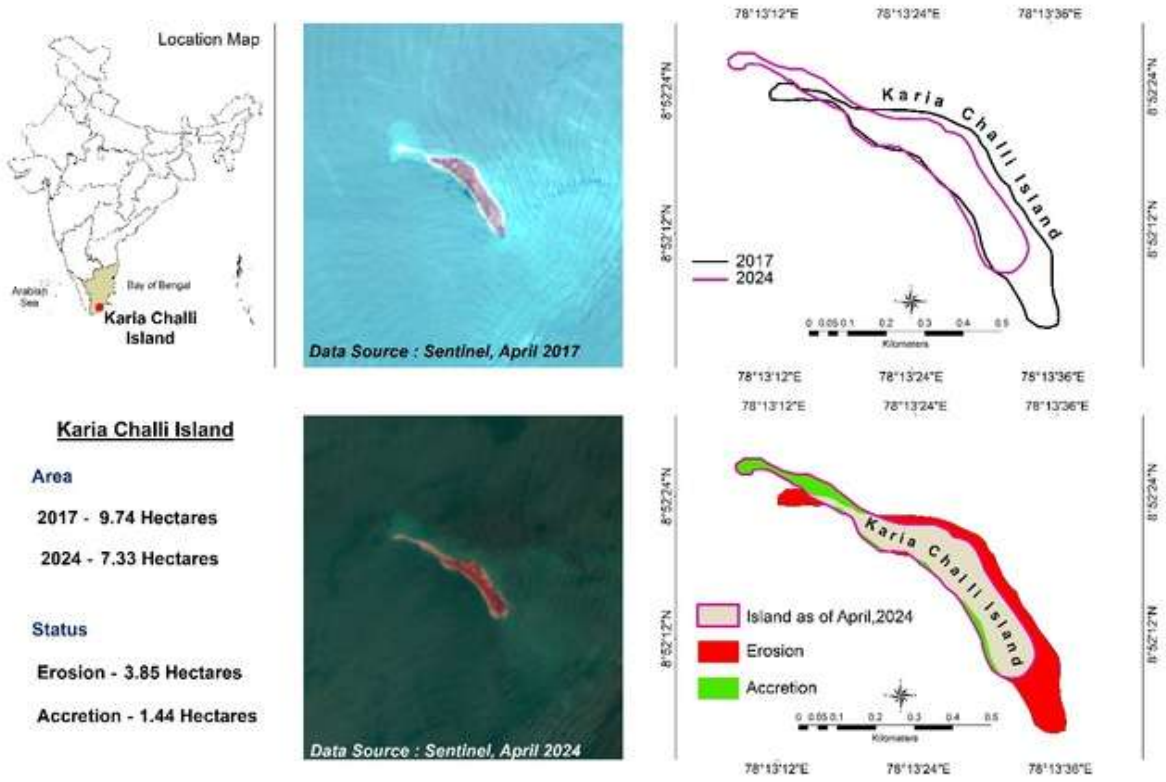


Figure 2: Sentinel Satellite images of Kariachalli Island for the years 2017 and 2024.

1.4 Need for the sub-project

Over the years, due to the combined effects of climate change and anthropogenic activities (coral mining, destructive fishing methods, seaweed collection, commercial shell collection etc), have degraded large coral reef areas around the island and their loss reflects on the island's stability and the livelihood of the fisher folk. The loss of coral habitats has led to the

reduction in island shore protection capacity and thereby to increased erosion and reduced island area.

The loss of the island and the surrounding coastal ecosystems will result in the depletion of fish populations and leave the dependent coastal community vulnerable. Hence, climate change adaptation practices are needed (i) to protect this Island from submergence, (ii) to restore the degraded coastal habitats like coral reefs and seagrass beds and (iii) to make the coastal communities resilient to and withstand the vagaries of climate change.

2. Description of the sub-project activities

The project's Kariyachalli Island restoration initiative is structured around a series of carefully planned interventions and activities, aimed at restoring the submerging Island and sustaining the ecological and economic benefits for a long term use. The proposed actions and their anticipated outcomes are outlined hereunder:

2.1. Design of AR modules and deployment and the alternatives

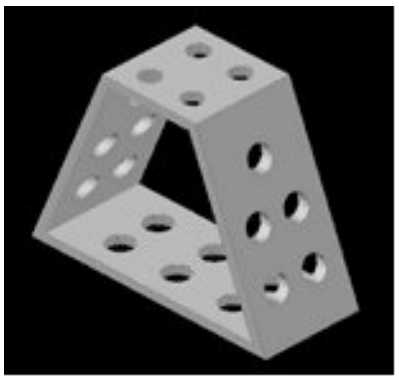
The Artificial Reef (AR) modules are one of the most proven structures in dampening wave forces to arrest the erosion and help in maintaining the Island area. They also facilitate biological growth besides providing shelter for juvenile fishes and forming as a breeding ground. Leaving the island without intervention like deployment of AR modules will lead to disappearance of Island which is not in the interest of protecting the nature. The materials like steel and cemented will have ISI marks ensuring good quality and least impact on marine environment. A picture of a modules shown in Fig 3. Similar types of modules were fabricated and deployed on Vaan Island which is about 14 km south of Kariachalli Island. Between 2015 and 2019 10600 AR modules were deployed to protect the Island from erosion. The project has been found to be successful. Bathymetry survey in 2022 around the Vaan Island, indicated that between the Island shore and the AR module deployed site, the depth has reduced from 2.5m to 0.5 indicating accretion of sand which is essential to absorb wave forces to protect the island from erosion.

Based on this experience keeping local bathymetric conditions two sizes of AR modules have been designed using modelling techniques to dampen the wave forces and 8500 AR modules are proposed in an alignment to suit the Island topography and wave climate prevailing in the area (Fig 4). The alignment is also based on wave modelling studies to ensure that the wave forces dampened without affecting the coral reef behind. The alternative to the AR modules is geotube with gabions filled with sand. Though it is an environment-friendly soft solution, the life of the geotube is short and the settlement of calcareous corals over the tubes may puncture them releasing the sand into the sea. Recurrent deployment of geotubes will be infructuous. Further, AR modules facilitate more settlement of benthic organisms, algae etc., besides forming a shelter for fish to escape from the predators. It is a better fish aggregating device than geotube.

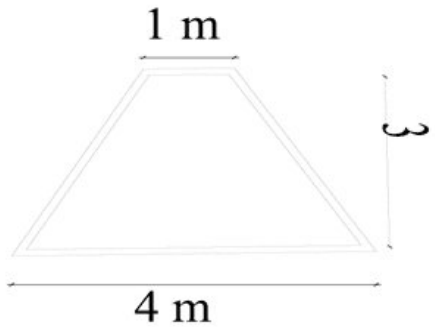
The proposed key activities are as follows

- Underwater fixing of AR deployment location (southeast of the Kariyachalli Island) as per the layout, avoiding coral area based on wave modelling studies (**Figure 4**).

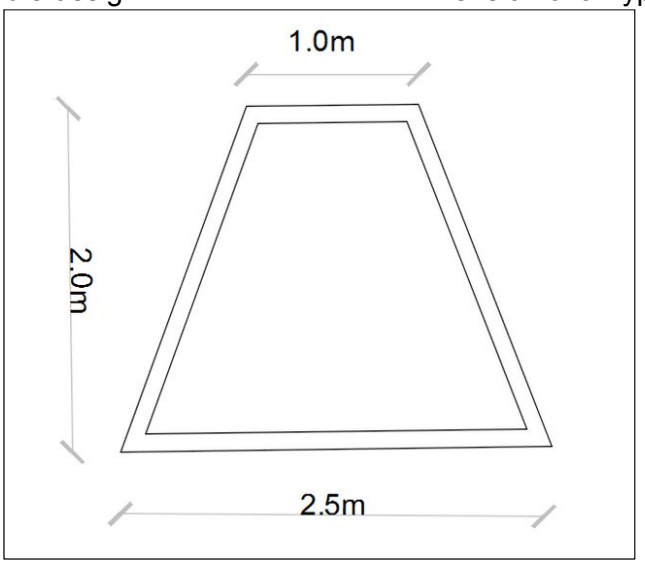
- Construction of 8,500 multipurpose Artificial Reef modules as per the dimensions (Two types of modules are designed as an artificial coral reef. Type 1 with the dimensions of 2.5 m width, 2 m height and 1 m longitudinal length. Type 2 with the dimensions of 4.0 m width, 3 m height and 1 m longitudinal length)
- Transportation and deployment of AR modules in the location as per the layout
- Monitoring, during and after the deployment of AR modules, various parameters such as marine water and sediment qualities, coral and seagrass habitats, island morphology, bathymetry and fishery.



AR module design



Dimension of a Type 2 unit of reef



Dimension of Type 1 unit of reef

Figure 3: Artificial Reef module design and dimensions

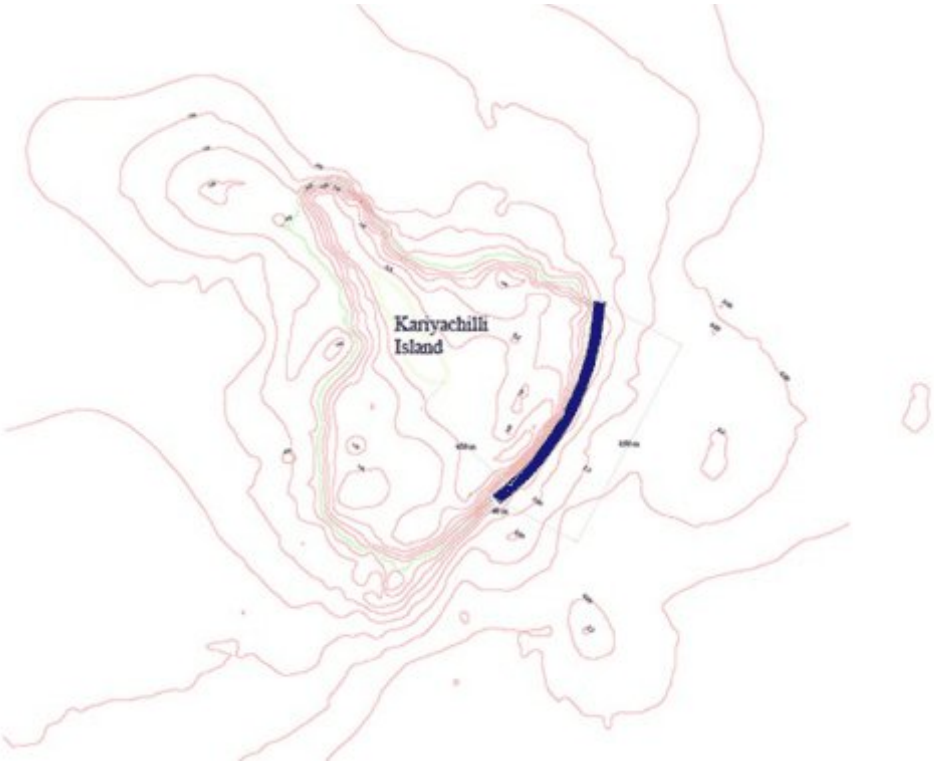


Figure 4: Proposed location of AR modules in Kariyachalli Island

The deployment of AR units involves two major activities within the marine zone: (i) The transportation of artificial reef modules to the deployment site from shore and (ii) Deployment of artificial reef modules at the site. Constructed/ fabricated artificial reef modules will be transported from the construction yard to the nearby shore (probably Tuticorin Old Harbour) and from there will be loaded on a barge with the help of derrick cranes equipped in the barge itself. Mechanized vessel (trawler) will be involved in towing the barge to the proposed deployment site on the Kariyachalli Island.

2.2. Coral Rehabilitation

To restore Habitats (Coral rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy. Key activities are as follows

- Selection of specific rehabilitation site within the identified degraded coral reef area by underwater survey
- Construction of concrete frames and cement slabs as substrates for fragment transplantation (Figure 5)
- Deployment of substrates
- Coral transplantation
- Monitoring and maintenance of rehabilitated sites

The substrates (concrete frames) for coral rehabilitation

Cement slabs for coral fragment transplantation

Figure 5: Photos showing concrete frames and cement slabs

2.3. Seagrass Rehabilitation

To restore Habitats (seagrass rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy. Key activities are as follows

- Selection of specific rehabilitation site within the identified degraded seagrass area by underwater survey
- Development of transplantation substrate (PVC frame / Coir ropes)
- Seagrass shoots transplantation
- Monitoring and maintenance of rehabilitated sites

PVC frame tied with seagrass shoots using jute rope

PVC frames and fixing of PVC Frames on seafloor

Figure 6: Photos showing PVC ropes and robes used to fix spigs

2.4. Eco development activities among coastal communities

To enhance the coastal communities' adaptive capacity and to sustain livelihood and food security. Key activities are as follows

- Self Help Group (SHG) related activities, which will include areas such as micro-credit provision, revolving funds, SHGs nurturing wherein alternate livelihood[1] opportunities will be generated for the communities.
- Conservation of marine ecosystem through awareness creation for SHGs
- Reviving and nurturing SHGs

[1] Fishing communities of Gulf of Mannar have been engaged in various fishery like chunk fishery in the past for their livelihood which are now banned. Only dead shells are allowed for collection. As it has caused reduction in their income, alternate sources of livelihood opportunities esp through women SHGs were initiated and being continued.

- Extending SHG loans to fishermen
- Construction of community hall, training facility and fish auction facility
- Imparting specific local skill upgradation training to fisherwomen SHG members (i.e. tailoring, embroidery, etc.)
- Imparting vocational training to fisher folk youth
- Biodiversity and SCUBA diving training
- Eco tourism and construction of interpretation-cum-training centre to carry out dissemination of information regarding GoM.
- Marine ornamental fish breeding with Clown Fish, Sea Bass, etc.
- Cage fish culture

Intended Outcomes.

- Erosion reduction and protection of Kariyachalli Island from further erosion and submergence; enhanced biodiversity particularly through facilitating natural coral recruitment for increase of coral diversity and density; improved fish production
- Enhanced live coral cover and biomass; restoration of ecological services like fish production and other biodiversity habitats
- Reduced impacts of island erosion
- Improved adaptation to withstand climate change impacts such as erosion
- Enhanced seagrass cover and biomass; restoration of ecological services like fish production and other biodiversity habitats
- Reduced impacts on nearby coral reef and thereby reduced island erosion
- Improved adaptation to withstand climate change impacts such as erosion
- Enabling coastal community to adapt for effectively overcoming climate change impacts

2.5. Project objectives and activities

The TN-SHORE project will enhance (i) the restoration of degraded coastal habitats and strengthen climate adaptation, (ii) promote resilience, and (iii) enhance the livelihood sustainability of Kariyachalli Island.

The key project activities are

- Deployment of multipurpose artificial reef modules in Kariyachalli Island in order to protect and restore this eroding island and to enhance the coral-associated biodiversity in particular fish production to help build livelihood sustainability for the benefit of small-scale fishers through incremental fish production, and to maintain ecological balance.
- Restoration of the ecological services through rehabilitation of degraded coral reefs and seagrasses around Kariyachalli Islands as options for climate adaptation and provision of stable substratum to protect Kariyachalli Island.
- Promotion of eco-development activities among the coastal communities to enhance their adaptive capacity so that they can have sustained livelihood and food security.

2.6. Structure of the Report

- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Description of the project
- Chapter 3: Legal and regulatory framework

- Chapter 4: Baseline Environment and Social
- Chapter 5: Potential Impacts and Mitigation Measures: Environmental and Social
- Chapter 6: Stakeholder Consultation and Disclosure
- Chapter 7: Environmental & Social Management Plan (ESMP)
- Chapter 8: Grievance Redressal Mechanism
- Chapter 9: Institutional Arrangement

2.7. Project Implementation and Schedule

The implementation of the project is planned over a four-year period, encompassing comprehensive planning, construction, transportation, and deployment and data collection phases. The schedule is designed to ensure systematic progress and effective monitoring of project milestones.

Implementation Timeline:

(i) **First Cycle (1st January 2025 to 31st March 2025)**:

- Preparation for sub-project activities such as detailed planning and procurement for AR construction and deployment, selection of specific sites for coral rehabilitation and seagrass rehabilitation, and Initiation of eco-development activities.
- Preparation for the construction of AR modules of sizes 2.5m x 1m x 2m (4250 Nos) and 4m x 1m x 3m (4250 Nos) which includes preparation of the construction site, development of facilities at the construction site and fabrication of AR moulds.
- Preparation of deployment of AR modules which include selection of sites near seashore for transport to Kariyachalli Island and arrangement of vehicles, cranes and barge and adequate manpower.
- Preparation for construction of concrete frames and cement slabs for coral rehabilitation which include fabrication of moulds.
- Preparation for construction of quadrats for seagrass rehabilitation.
- Monitoring of various parameters (baseline) such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, biodiversity monitoring in, on and around AR modules, island morphology, bathymetry and fishery will be carried out.
- Preparation to initiate eco development activities such as micro-credit provision, reviving and nurturing SHGs, extending SHG loans to fishermen, conservation of marine ecosystem through awareness creation for SHGs, construction of community hall, training facility and fish auction facility, biodiversity and SCUBA diving training, imparting specific local skill upgradation training to fisherwomen SHG members, imparting vocational training to fisher folk youth, ecotourism and construction of interpretation-cum-training centre to carry out dissemination of information, marine ornamental fish breeding and cage fish culture,
- Construction and deployment of a total of 1700 AR modules will be completed.
- A total of 1000 concrete frames and 12000 cement slabs for coral rehabilitation will be completed. Transplantation of corals on 500 numbers of concrete frames will be completed.
- A total of 3000 quadrats for seagrass rehabilitation will be prepared and rehabilitation on 1500 quadrats will be completed.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be initiated.

(ii) **Second Cycle (1st April 2025 to 30th September 2025)**:

- Construction and deployment of a total of 3400 AR modules will be completed.
- Monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, biodiversity monitoring in, on and around AR modules, island morphology, bathymetry and fishery will be continued.
- Transplantation of corals on 500 number of concrete frames will be completed.
- Seagrass rehabilitation on 1500 quadrats will be completed.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued

(iii) **Third Cycle (1st October 2025 to 31st March 2026):**

- Construction and deployment of a total of 3400 AR modules will be completed.
- Monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, biodiversity monitoring in, on and around AR modules, island morphology, bathymetry and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(iv) **Fourth Cycle (1stApril 2026 to 30th September 2026):**

- Monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, island morphology, bathymetry, biodiversity monitoring in, on and around AR modules, and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(v) **Midterm Review (September 2026)**:Review on construction and deployment of AR modules, coral and seagrass rehabilitation, monitoring various parameters on AR modules and rehabilitation sites and eco-development activities

(vi) **Fifth Cycle (1st October 2026 to 31st March 2027):**

- Monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, island morphology, bathymetry, biodiversity monitoring in, on and around AR modules, and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(vii) **Sixth Cycle (1st April 2027 to 30th September 2027):**

- In this period, monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, island morphology, biodiversity monitoring in, on and around AR modules, bathymetry and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(viii) **Seventh Cycle (1st October 2027 to 31st March 2028):**

- In this period, monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, island morphology, bathymetry, biodiversity monitoring in, on and around AR modules, and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(ix) **Eighth Cycle (1st April 2028 to 30th September 2028):**

- In this period, monitoring of various parameters such as marine water and sediment quality, status of coral reefs, seagrasses and associated biodiversity, Island morphology, bathymetry, biodiversity monitoring in, on and around AR modules, and fishery will be continued.
- Monitoring and maintenance of coral and seagrass rehabilitation sites will be continued.
- Mentioned eco-development activities will be continued.

(x) **Final Review (September 2028):** Assessment of sub-project outcomes, analysis of data, and preparation of final reports.

(xi) **Implementation Duration: 4 Years (48 Months)**: Throughout the sub-project duration, regular monitoring and evaluation will be conducted to ensure adherence to the schedule and to assess the effectiveness of the sub-project activities. The implementation arrangements are designed to facilitate a structured and phased approach to achieve the sub-project's objectives, with a focus on enhancing the ecological integrity of coastal ecosystems and contributing to the sustainable management of the resources.

(xii) A bar chart showing the timeline is placed in **Annexure 1**

3. Legal and regulatory framework

In this Chapter, the prevailing key National, State level laws, rules, policies, Acts, notifications pertaining to environmental, climate change and social aspects have been reviewed for their applicability to the proposed Deployment of Artificial Reef structures to control erosion and to protect and restore the Karyachalli Island is provided in the following Table 2.

3.1 Clearances / Permissions for Competent Authority

The Gulf of Mannar Marine National Park (GOMMNP) falls within the CRZ 1A category under the Coastal Regulation Zone Notification where most of the project activities will be carried out and thus the sub project activities require clearance from Tamil Nadu State Coastal Zone Management Authority (SCZMA). Moreover, the sub-project site also falls under the Category II of the IUCN/Protected area status. However, there will not be a requirement for clearances from IUCN as the sub-project activities such as the deployment of artificial reefs, coral restoration and seagrass restoration will happen within the national boundary.

3.2. National and State Laws, Regulations and Policies

National and state laws and policies that are applicable to the project is given in the following table 2

Table 2: Relevancy of various Environmental Legislations under (Government of India and Government of Tamil Nadu

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
1.	Environment (Protection) Act, 1986	EPA (1986) is an umbrella Act that provides for introduction of various regulations aimed at environmental conservation and protection	**Applicable** to this project because investment is likely to happen in conservation & restoration, erosion control and coral restoration which requires construction materials at site. Consent to Establish (CTE), Consent to Operate (CTO) from the Pollution Control Board during construction and operation phase of the project, applicable standard of ambient Air, water, noise quality standard (published by CPCB) shall be applied under this act.
2.	Water (Prevention and Control of Pollution) Act 1974, amendments	This Act is applicable for maintaining or restoring wholesomeness of water. Central Board and state board are empowered to enforce them	
3.	Air (Prevention and Control of Pollution) Act 1981	Applicable to reduce Air pollution during construction, operation phases of the project. The Rules are applicable as the construction related activities supported by the project have the potential to create air pollution.	
4.	The Noise Pollution (Regulation and Control) Rules 2000	Applicable to reduce noise pollution during construction, operation phases of the project. The Rules are applicable as the construction related activities supported by the project have the potential to create noise pollution.	
5.	Coastal Regulation Zone Notification, 2011 & 2019.	The Notification makes it mandatory clearance for project activities lying in CRZ Zones from SEIAA, GoTN or MoEF &CC.	**Applicable.** The GOMMNP falls within the CRZ IA where most of the project activities will be carried out and thus the

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
			project activities require clearance from Tamil Nadu State Coastal Zone Management Authority (SCZMA). Project activities such as the deployment of artificial reefs, coral restoration and seagrass restoration will happen within the boundary of the GOMMNP and hence permission is needed to be obtained from the Chief Wildlife Warden of the Tamil Nadu Forest Department
6.	Indian Forest Act 1927	This act enables the state to acquire ownership over forests and their produce and regulates access, use and extraction of forest resources for consumptive use. Section 26 of this act restricts grazing to only identify grazing units or in adjoining forest ranges.	**Applicable,** one of the sub project components includes plantation of seagrass, which is a feed for dugongs (similar to grassing in forest land)
7.	The Indian Wildlife (Protection) Act, 1972	Applicable for protection to listed species of flora and fauna and establishes a network of ecologically important Protected Areas (PAs) Under section 33 of WLPA, 1972- Control of sanctuaries. The Chief Wildlife Warden shall be the authority who shall control, manage and maintain all sanctuaries and for that purpose, within the limits of any sanctuary, may construct such roads, bridges, buildings, fences or barrier gates and carry out such other works as he may consider necessary for the purposes of such sanctuary.	**Applicable**, to ecotourism/ ecological refreshment activities planned in close proximity to/inside of the boundary of National Park, Wildlife sanctuary/biosphere areas. This act will be applicable in eco-tourism activities involved in NP, WLS, and requisite wildlife approval from SBWL/NBWL shall be applicable.
8.	Occupational safety, health administration and working Conditions code, 2020	Regulating the occupational safety, health and working conditions of the persons employed in an establishment and for matters connected therewith	**Applicable, Covers OHS aspects for all workers including inter-state** Labour and management during construction and operation phases of the project will fall under purview of this code.
9.	Forest (Conservation) Act, 1980, revised guidelines of 2004, 2014, 2017 and amendment 2023	Permits judicious and regulated use of forest land for non-forestry purposes.	**Applicable** The project is envisaged to protect and restore the island and coral reef. As per section 2 of the Act, the activities related to any work relating or ancillary to conservation, development and management of forests and wildlife is allowed.
10.	Tamil Nadu Forest Act 1882 & amendments	Envisaged to consolidate the law relating to forests, the transit of forest-produce and the duty leviable on forest produce &	

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
		Declaration of RF, PF	
11.	Biological Diversity Act 2002, and Biological Diversity Rules, 2004	Applicable for conservation of biological diversity, sustainable use of its components, fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto.	**Applicable** project activities having to access biological resources near the environmental sensitive areas including national parks, wildlife sanctuaries and biodiversity heritage sites, causing erosion of the ecosystem and environmental damage. Biological Management Committees (BMC) and people's biodiversity register are two important aspects of this rule. Biodiversity Management plan is prepared by BMC based upon People's biodiversity register. In case of any activity planned, it is mandated to share of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith.
12.	The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act 1996	This Act provides for safety, health and welfare measures of buildings and construction workers in every establishment which employs or employed during the preceding year ten or more such workers. These measures include fixing hours for normal working day, weekly paid rest day, wages for overtime, provision of basic welfare amenities like drinking water, washrooms, urinals, crèches, first aid, canteens, and temporary living quarters within or near the work site.	**Applicable**, this project involves labours during construction stage.
13.	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	This international convention, to which India is a signatory category, lists the endangered flora and fauna and regulates trade of these species.	**Applicable,** since the project involves conservation & protection of species.
14.	Fisheries Act, 1983	An act to provide for protection, conservation and development of fisheries in the State and for matters connected therewith or incidental thereto.	**Applicable,** as project involves conservation of coastal ecosystem including fish.
15.	Tamil Nadu Maritime Board	Considering wrecks & causalities along the cost of Tamil Nadu	**Applicable**
16.	Motor vehicle act, 1988	Granting permission for usage of vehicles. As all the projects requires vehicle for commutation, the vehicle act also to be followed.	**Applicable**

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
17.	Plastic waste management rules	Stipulate minimum thickness of plastic carry bags, its collection & recycle.	**Applicable**
18.	National Action Plan on Climate Change (30.06.2008) TNSAPCC, 31.03.2015	India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. India, in 2008, has set up National Action plan on climate change (NAPCC) which outlined policies aimed at sustainable growth and dealing with climate change concerns effectively. NAPCC outlines eight national missions to address various adaptation and mitigation measures pertaining to Solar Energy, Enhanced Energy Efficiency, Sustainable Habitat, Water, Sustaining Himalayan Ecosystem, Green India, Sustaining Agriculture, and Strategic Knowledge on Climate Change.	**Applicable**
19.	Tamil Nadu Act 039 of 2002: Tamil Nadu Prohibition of Harassment of Woman (Amendment) Act, 2002	This is an amendment of Eve teasing Act, 1988 which is substituted with women's harassment.	**Applicable as w**omen are involved while fabricating concrete structures
20.	Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013	The act is meant to serve as guidelines for the employees subject to the provisions of the Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013.	**Applicable as w**omen are involved while fabricating concrete structures
21.	Child Labour (Prohibition and Regulation) Act, 1986	The act prohibits employment of children (those who have not completed their fourteenth year) in certain occupations and processes (part II, Section 3). The Act also specifies conditions of work for children, if permitted to work.	**Applicable** Children/ child labour will not be involved..
22.	Tamil Nadu Child Labour (Prohibition and Regulation) Rules, 2016 and its subsequent amendments.	States that all type of child labour below 14 years should not be employed enforced by labour & employment department.	**Applicable** Children/ child labour will not be involved.
23.	The Bonded Labour System (Abolition) Act 1976	States that all forms of bonded labour stand abolished, and every bonded labour stands freed and discharged from any obligations to render any bonded labour	**Applicable**

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
24.	Minimum Wages Act, 1948	This Act provides for fixing minimum rates of wages and associated rules in employments.	**Applicable**
25.	Workmen's Compensation Act, 1923 & Rules 1924	The act requires if personal injury is caused to a workman by accident arising out of and during his employment, his employer should be liable to pay compensation in accordance with the provisions of this Act.	**Applicable**
26.	The Contract Labour (Regulation and Abolition) Rules, 1971	The act requires every principal employer of an establishment to make an application to the registering officer in the prescribed manner for registering the establishment. The Act and its Rules apply to every establishment in which 20 or more workmen are employed on any day on the preceding 12 months as contract labour and to every contractor who employs or who employed on any day preceding 12 months, 20 or more workmen. It does not apply to establishments where the work performed is of intermittent or seasonal nature. An establishment wherein work is of intermittent nature will be covered by the Act and Rules if the work performed is more than 120 days in a year, and where work is of a seasonal nature if work is performed more than 60 days in a year.	**Applicable.**
27.	The Right to Information Act, 2005	The act provides for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority	**Applicable**
28.	Code on Wages, 2019	Code on wage rules as of 2022 issued by labour welfare & skill development department to ensure that the workers are paid fairly as per rules.	**Applicable**
29.	Occupational Safety, Health and Working Conditions Code, 2020	To ensure that all labour is given suitable induction to skill jobs along with PPE, ear muffs, etc., as per Occupational Safety and Health Administration (OSHA) norms (https://www.osha.gov/laws-regs/interlinking/standards/1926.2	**Applicable**

Sl.no	Name of relevant Act/Policies/Rules	Objective	Relevance to Subproject Interventions
Environmental, climate change and Social Rules and Regulations			
		8).	

The relevance of sub-project activities to various ESSs and gaps with respect to country regulations are described below in Table 3.

Table 3 Comparison between ESS and National regulations

Sl.no	ESS	Policy Gaps in National regulations
1.	ESS 1 Assessment and Management of Environmental and Social Risks and Impacts	As per the Coastal Regulation Zone Notification, 2011 & 2019, the GOMMNP falls within the CRZ IA where most of the project activities will be carried out and thus the project activities require clearance from Tamil Nadu State Coastal Zone Management Authority (SCZMA). Gaps with national systems exist regarding assessments, consultations and monitoring. The following additional measures will be required • Conduct an environmental and social assessment of the proposed sub-project duly identifying impacts and risks • Undertake stakeholder engagement and disclose appropriate information following ESS10 • Develop project level GRM in accordance with SEP • Develop an ESCP, and implement all measures and actions set out in the ESCP (part of the legal agreement) • Conduct monitoring and reporting on the environmental and social performance of the sub-project against the ESS
2.	ESS 2: Labour and Working Conditions	The National legal provisions almost cover all requirements in ESS2 except relating to community workers and a functional GRM for different types of workers. Hence, an overall project-level Labour Management Procedure (LMP) will be prepared by the contractor to meet the ESS2 requirements
3.	ESS 3: Resource Efficiency & Pollution Prevention and Management	The majority of ESS3 requirements are addressed directly by existing regulations and indirectly for resource efficiency, pollution prevention, and management aspects.
4.	ESS 4: Community Health and Safety	National and State Acts covers all ESS 2 and ESS 4 requirements, gaps exist for community exposure to health issues. However suitable mitigation measures are provided in the ESMP
5.	ESS 5: Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement	***ESS 5 is not applicable for the sub-project***. However in general, the gap exists specifically related to aspects such as identification of non-titleholders as PAPs; cut-off dates for non-

Sl.no	ESS	Policy Gaps in National regulations
		titleholders and valuation of structures with depreciation
6.	ESS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	No specific Gaps to be addressed as policy/regulations support biodiversity conservation and livelihood based on these exist.
7.	ESS 7: Indigenous Peoples/ Sub-Saharan African Historically Underserved Tradition Local Communities	Not applicable
8.	ESS 8: Cultural Heritage	No gaps exist as existing regulations guide the protection of cultural heritage. Provisions from the National Act meet the ESS 8 requirements
9.	ESS 9: Financial Intermediaries	Not Relevant
10.	ESS 10: Stakeholders Engagement and Information Disclosure	There is a provision of public hearing in EIA notification 2006. However, the statutory process does not require the preparation of a SEP or equivalent document as well as conducting meaningful consultations and information disclosure, that is accessible to all stakeholders

3.3. Applicability of the World Bank Environmental and Social Framework

The relevance of Environmental and Social Standards (ESS) applicable to this sub-project is detailed in the following table.

Table 4: Applicability of Environmental and Social Standards (ESS) and Trigger Criteria

ESS Applicability & Triggers	
ESS	**Relevancy with Reasons**
ESS 1: Assessment and Management of Environmental and Social Risks and Impacts	**Relevant**: Interventions are within fragile ecosystems (marine protected areas) and Coastal Regulation Zone (CRZ) I A, involving the transplantation of foreign materials (AR modules) and potential disturbance to existing habitats. (https://parivesh.nic.in/#/crz)
ESS 2: Labour and Working Conditions	**Relevant**: Activities require skilled labour and divers for the deployment of AR modules, and materials for coral and seagrass rehabilitation. They will be from local areas. An exclusive GRM for labours will be proposed, which allows the labours to share their grievances with respect to the sub-project. The GRM also accepts queries, suggestions, positive feedback, and concerns of project-affected parties like stakeholders related to the environmental and social performance of the project
ESS 3: Resource Efficiency, Pollution Prevention and Management	**Relevant**: The deployment of artificial substrates may cause localized sedimentation.

ESS Applicability & Triggers	
ESS	**Relevancy with Reasons**
ESS 4: Community Health and Safety	**Relevant**. The land based activities like fabrication of concrete and cement structures like Artificial reefs, frames for coral reef restoration involve movement of materials through trucks or other means and also dust created during construction may pose health risk to the people nearby and also the passerby. The proposed activities shall be managed through local labours and hence the need for the labour camp or rental accommodation may not be required. .
ESS 5: Land Acquisition, Restrictions on Land use and Involuntary Resettlement	**Not Relevant**: The sub-project activities are situated within seawater, with no land acquisition involved. As the fishing community is aware that fishing is not allowed around the Island (1 km around), they do fishing beyond this zone and hence there would be no impact on their livelihood. Further the proposed activities do not affect the navigation of fishing boats. Barren/empty land far (preferably government land) from the human habitation or rented land from private landowners, will be temporarily used for the construction of AR modules. Hence there will be no land acquisition or economic displacement
ESS 6: Biodiversity conservation and Sustainable Management of Living Natural resources	**Relevant**: Activities are located within CRZ I A fragile ecosystems. Proposed activities will not cause any damage to the fishing activities in the sub-project site as the site is already prohibited for commercial fishing. Minor impacts may be caused by fishing activities during the transportation of AR modules from the shore to the deployment site.
ESS 7: Indigenous Peoples/ Sub-Saharan African Historically Underserved Tradition Local Communities	Not Relevant
ESS 8: Cultural Heritage	Not Relevant. The cultural locations are on mainland and far away from the sub-project site. physical component of the sub-project will not have a material impact on any fishing practices, representations, expressions, knowledge, skills etc.
ESS 9: Financial Intermediaries	Not Relevant
ESS 10: Stakeholder Engagement and Information Disclosure	**Relevant**: Engagement with stakeholders and information disclosure is integral to the sub-project activities. The fishing community are the stakeholders and they will be informed about the activities especially movement of barges carrying the deployment structures so that they can deploy the fishing nets well away from the route. The revolving credit scheme is being continued and hence such aspects will require engagement with stakeholders. A Labour GRM will be formed to sort out the issues of the labours and the contractor and the local communities. Its roles and responsibilities are detailed in Chapter 8

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4. Environmental and Social Baseline

This chapter presents the baseline data required to understand the environmental, ecological attributes and socio-economic characteristics of the study area. The baseline includes climate, meteorology, rainfall, soil, flora, fauna and social profile of the local population. The objective is to comprehend the current environmental conditions and socio-economic status of people which would help in comparing and assessing the impacts on E&S aspects caused by the sub-project in the construction and operation stages.

4.1 Methodology

The baseline information has been collected from the primary and secondary sources and for the E&S screening of the sub-project site.

The desk review of the available documentation and reports of this sub-project is carried out including the Detailed Project Report. The primary surveys were conducted in the study area to identify the Potential /Temporary Impact types and duration of impacts, etc..

The assessment was conducted in eight island reef sites in Kariyachalli and the nearby Vilanguchalli Islands and seventeen seagrass sites within the 5 km radius of the Island. Apart from the island reefs, there are a few patch reef sites lying within the 5 km radius of Kariyachalli Island. A total of 9 patch reefs were observed in the reef habitat located between shore and marine zone, extending between shallow and deeper water up to 8 km distance from the shore. Thus, a total of 17 seagrass stations and a total of 17 coral reef stations were fixed to conduct the seagrass and coral reef survey. Four stations were fixed for estimating the environmental parameters.

The temperature of the water samples was measured using a standard mercury-filled thermometer with 0.1°C accuracy, and their pH was measured using a pen-type pH tester (Hanna hand pH meter). Salinity were estimated using a hand-held refractometer (ERMA, Japan). Turbidity was analyzed by Turbidity meter (LUTRON TU-2016) accordance to IS: 3025 (Part 10) - Reaffirmed 2002. Total suspended solids (TSS) were determined by weighing the residue after the evaporation of 100 ml filtered water samples. Dissolved oxygen (DO) was estimated by hotspot field analysis using a hand-held DO meter (LT Lutron, DO-5509 Taiwan) and Winkler's methods. Determination of chemical oxygen demand (COD) using COD Digester followed by a titrimetric method (APHA, 1998). Dissolved oxygen level in the water samples was estimated by Winkler's method (Strickland and Parsons, 1972). Dilution method was followed to determine the BOD. For all the analyses we followed the protocols of American Public Health Association (APHA, 1995). Calcium and magnesium were measured by complexometric titration Murphy and Riley (1962). Nutrients such as the nitrite (NO_2) was measured by a colorimetric method using sulfanilamide, nitrate (NO_3) by the cadmium reduction method using a (Agilent Cary UV) double-beam spectrophotometer following Strickland and Parsons (1972). Chloride (Cl) was determined by volumetric titration using $AgNO_3$ and K2Cr, HCO3 and carbonate (CO_3) was determined by Portamess using HCl, phenolphthalein, methyl orange by titration method. Oil and grease in water samples were analyzed following SANS (2007). The pH of sediment samples suspension was determined using pH meter as described by Jackson (1958). Organic matter analyses in the sediment samples was performed in the laboratory using Loss on Ignition method according to Heiri et

al., (2001). Oil and grease contents in sediment were analyzed using the Soxhlet method (Zhang et al., 2015).

Total coliform bacteria (TC) were determined on Mac Conkey agar, and the plates were incubated at 35 ± 2 ◦C for 24 h. Phytoplankton samples were collected from the surface water by towing a plankton net number 30 of mesh size 60 µm (Sukhanova, 1978), for half an hour and the density was measured using a Sedwick Rafter counting chamber. Quantitative estimation of zooplankton was done using the Sedgwick rafter cell counting method. The samples analysis and pictures were captured with a digital camera under a binocular microscope at a magnification of about four times (4X) and zooplankton were identified using the keys of the standard publications of Kasturirangan (1963) and Santhanam and Srinivasan (1994). For benthic faunal analysis sediment was collected using a Peterson's grab and fixed with 10% formalin in seawater. The samples were transported to laboratory and filtered through 0.5 mm sieve to separate macro benthos. Then the samples of macro benthos were transferred into 10% formalin containing Rose Bengal stain for quantitative identification (McIntyre 1965, Aswandy et al., 1991 and Zaleha et al., 2001). Trace elements or Heavy Metals like Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu) and Mercury (Hg) were analysed in water and sediment samples. All the above metals were analysed in Atomic Absorption Spectrophotometer and Mercury were analysed by cold vapour technique using Mercury Analyser attached to the AAS (WHO, 1995).

All underwater surveys were carried out using SCUBA diving and skin diving. Line Intercept Transect (LIT) method (English et al. 1997) was used to measure the cover of a benthic life form (such as corals) or group of life forms within a particular area by calculating the fraction of the length of the underwater line that is intercepted by that particular life form. Straight 20 m line intercept transects were laid in each coral reef site with a minimum of 20 m distance between each transect. The seagrass survey was carried out in the seagrass sites falling within the 5 km radius using transects and quadrats method (English et al. 1997). Individual shoots were counted underwater within the quadrats and shoot density was calculated as the number of shoots per m^2.

The macrofaunal and fish communities occupying the coral reefs and seagrass meadows were studied using standard monitoring protocols. The macrofaunal communities were assessed in the reefs and seagrass sites using haphazardly placed quadrats (1 X 1m) divided into 25 grids. Reef and seagrass associated fish communities occurring in the sub-project area were assessed using standard fish survey techniques. Fish survey was carried out in the reef habitats and seagrass meadows by using , 50x5m belt transect method (English et al., 1997). The references mentioned above are given in Annexure 2.

Additional data were collected from relevant websites. Data thus collected from the secondary sources are published literature, government documents, research reports/ journals, etc. were reviewed. The sources are specified in Table 6, The ground truthing to validate the satellite images were conducted in 2023.

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Table 5: Sources of Environmental and Social Data

S.No.	Attribute	Parameter	Source of Data
1	Land use /cover	Land use patterns	Satellite Imagery
2	Geology	Soil and mineral profile	Geological Survey of India
3	Air, water, noise, and soil	Measurement levels	Relevant departments (Tamil nadu pollution control board, Central groundwater board, Tamil nadu water supply and drainage board)
4	Meteorology	Temperature, rainfall, wind, etc.	IMD and other studies
5	Ecology	Existing terrestrial/ aquatic flora and fauna	Research papers/ journals
6	Socio-economic aspects	Socio-economic characteristics	Census of India, 2011; and District Handbook
7	Fisherfolk details	Demographic, educational and occupational details of fishermen	Marine Fisheries Census 2016 - Tamil Nadu.

4.2 Physical Environment

4.2.1 Climate

The sub-project area comes under Thoothukudi district, which is situated on the southern east coast of Tamil Nadu and is adjacent to Bay of Bengal. It has a tropical wet and dry climate (Table 6). The district generally experiences hot and humid climatic conditions. The humidity reaches its peak during the morning and is lowest in the evening. The months between April and June are generally hot with temperatures going up to an average maximum of 36.6 deg.C In winter (December to January) the average minimum temperature is 19.8 deg C. Monsoon season is between June to September, which brings heavy rains in the sub-project area coupled with cool breeze. Monsoon winters are largely cooler in comparison with other places in Southern India.

Table 6: Climate data for Thoothukudi

Month	Avg. Max Temp (°C)	Avg. Min Temp (°C)	Avg. Rainfall (mm)
January	30.4	22.6	8
February	32.2	22.9	29
March	34.6	24.5	16
April	35.2	26.1	48
May	39.0	27.3	28
June	35.0	27.0	4
July	33.9	26.6	4
August	34.2	26.5	3
September	34.4	26.1	14
October	33.0	25.2	136
November	30.5	23.8	238
December	30.0	23.0	93

Source: IMD

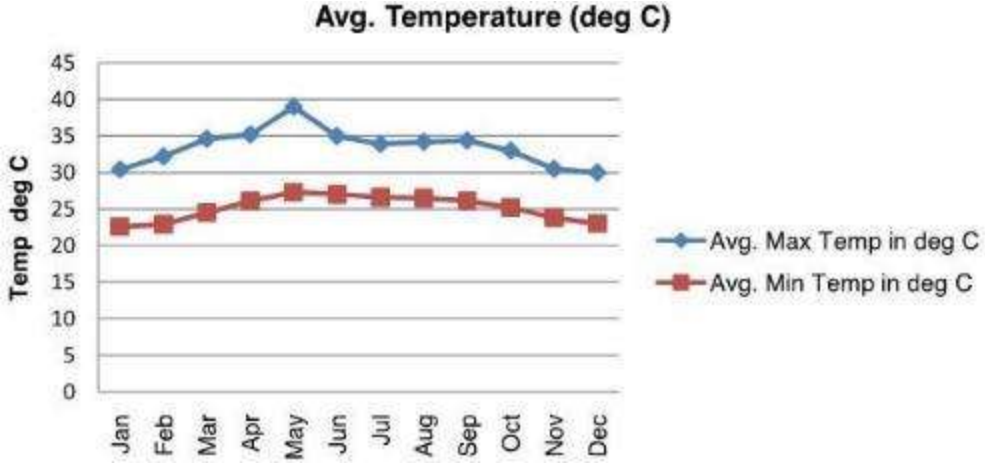


Figure 7: Graphical representation of yearly average temperature in degree C

4.2.2 Rainfall

The maximum precipitation is contributed by the Northeast Monsoon every year. The average annual rainfall in the sub-project area is 879mm (Source: India Meteorological Dept (IMD)

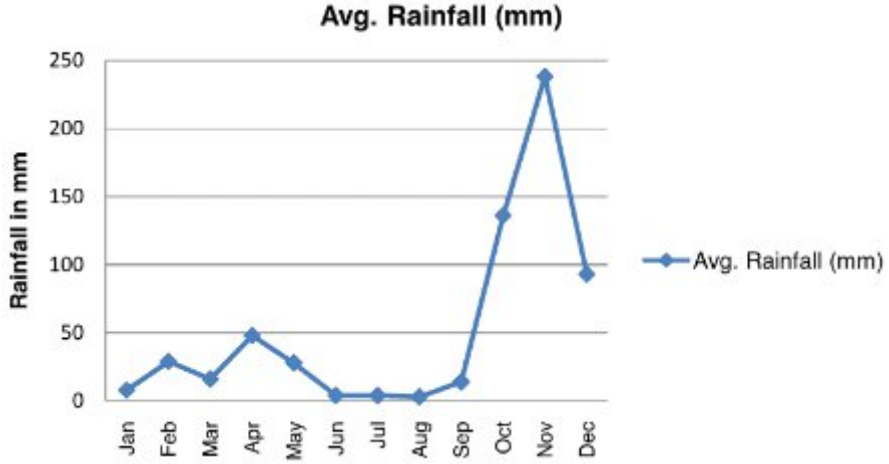


Figure 8: Graphical representation of yearly average rainfall in mm (Source IMD)

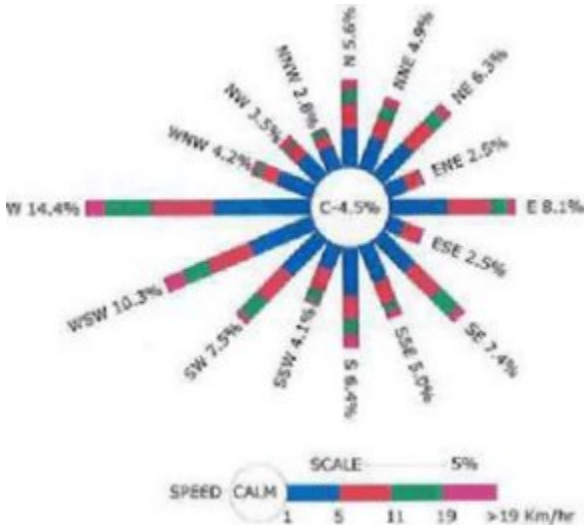


Figure 9: Windrose diagram

4.2.3 Wind speed direction

The available data indicate the trend of wind speed direction during pre-monsoon, monsoon, post monsoon and winter season in a year, windrose is shown in Fig 9.

4.2.4 Relative humidity

High relative humidity between 60% and 88% prevail throughout the year. 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., 80% to 85%. In the months of June, the humidity is lower i.e., around 30%. Average relative humidity recorded were 78%and 68% in the morning and evening respectively.

4.2.5 Cloud cover

Generally light clouds are observed in winter mornings. During pre-monsoon and the post-monsoon evenings the skies are either clear or lightly clouded. But in post-monsoon mornings as well as monsoon morning heavy clouds are commonly observed and, the skies are light to moderately cloud in the evening time throughout the year.

4.2.6 Soil

The soil is typical coastal sand, stream with shingles in places and there are swamps in places.

4.2.7 Wave Climate and its application in the design of AR modules

Wind waves are the basic forces that strike beaches and other coastal forms. The wave force if not subdued by formations like coral reefs in the Islands like Kariyachalli can lead to erosion of the coast. Coral mining in the past has led to increased wave forces (energy) on beaches of the Island leading to the current state of severe erosion. To absorb wave energy, it is essential to place structures like artificial reefs designed in such a manner so that wave energy on beaches is reduced and the erosion is controlled. To analyse the wave climate and to design structures to absorb/reduce wave energy, a wave dynamics study was conducted for the Kariyachalli Island with the help of IITMadras, Chennai. For this purpose, a numerical model which solves the mild slope equation is applied to identify the salient offshore points

near the islands, where the wave energy is concentrated due to the combined effect of wave refraction and diffraction. The model was also used to design the artificial reef modules.

The outcome of the study is the design of porous artificial reef in a triangular shape with openings for energy dampening which are to be deployed in the southeast part of the Island free from coral reefs (More details on the wave dynamics study are given in **Annexure 3**

4.2.8 Marine water and sediment qualities

Marine water samples have been collected at 4 stations surrounding the Kariyachalli Island (**Error! Reference source not found.**). The data are presented in Tables 7 and 8. The outcome of the analysis is discussed in the following paragraph.

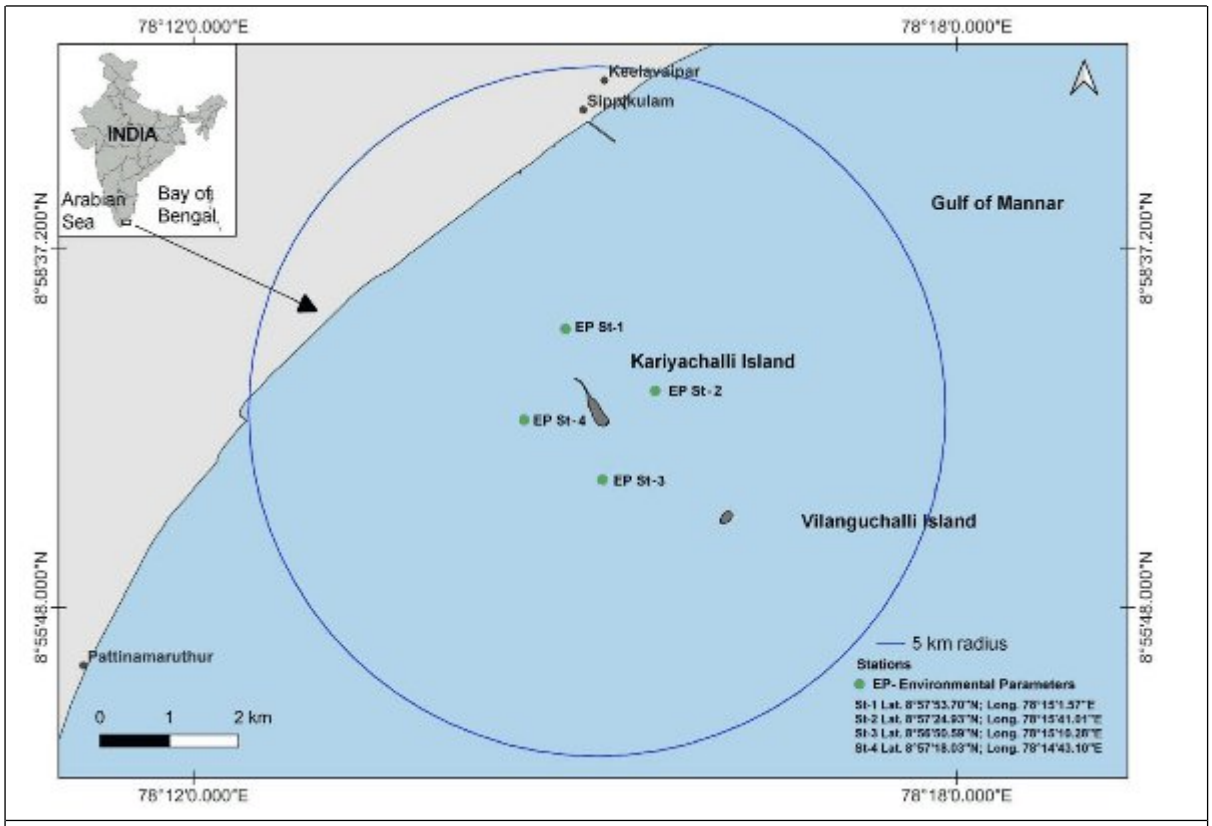


Figure 10: Map showing marine water and sediment sampling locations

Physical Properties. Water temperature was between 27.60°C and 27.90°C, with the highest level recorded in surface water of station 1, and the lowest level recorded in bottom water of station 4. Salinity was recorded around 34.50 ppt in all the stations. The pH level recorded was from 7.97 to 8.06, with the highest level recorded in the surface water of station 4 and the lowest level recorded in the bottom water of station 2. Turbidity was recorded from 5.15 to 6.22 NTU, with the lowest level recorded in the surface water of station 1 and the highest level in the bottom water of station 3. TSS was recorded between 89 and 116 mg/l, with the lowest level recorded in the surface water of station 1 and the highest level in the bottom water of station 4.

Chemical properties. Dissolved oxygen content was between 4.97 and 5.15 mg/l, in which the lowest level was recorded in the bottom water of station 2 and the highest level was recorded in surface water of station 2. Chemical oxygen demand was recorded from 1.25 to

1.39 mg/l, with the highest level recorded in the surface water of station 3 and the lowest level in bottom water of station 1. Biological oxygen demand was recorded from 1.8 to 2.10 mg/lm, in which the lowest level was recorded in station 2 and the highest level recorded in station 4. Calcium level was between 440 and 520 mg/l, in which the lowest level was recorded in the surface water of station 2 and the highest level was recorded in the bottom water of station 2. Magnesium content was recorded from 1258 to 1314 mg/l with the lowest level recorded in surface water of station 1 and the highest level recorded in bottom water of station 4. The highest level of nitrate was recorded in the bottom water of station 2 with 1.42 µg at/l and the lowest level was recorded, in bottom water of station 1 with 1.27 µg at/l. Nitrite level was between 0.39 and 1.05 µg at/l, with which the lowest level was recorded in surface water of station 2 and the highest level in surface water of station 3. Chloride level was recorded at around 17.64 g/l in all the stations. Oil and grease contents were between 0.27 and 0.41 mg/l, with the lowest level recorded in the bottom water of station 1 and the highest level in the bottom water of station 4.

Table 7: Physical and chemical properties of surface and bottom waters

Parameters	Station 1		Station 2		Station 3		Station 4	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Physical parameters								
Temperature (^{0}C)	27.9	27.8	27.8	27.7	27.8	27.7	27.7	27.6
Salinity (ppt)	33.5	34	34.5	34	34	34.5	33.5	34
pH	8.02	7.99	8.05	7.97	7.98	7.97	8.06	8.02
Turbidity (NTU)	5.15	5.96	5.26	5.97	5.57	6.22	5.55	6.17
TSS (mg/l)	89	97	100	114	102	113	105	116
Chemical parameters								
DO (mg/l)	5.1	5.09	5.15	4.97	5	5.12	5.05	5.11
COD (mg/l)	1.35	1.25	1.33	1.27	1.39	1.34	1.28	1.36
Calcium (mg/l)	480	500	440	520	490	500	460	480
Magnesium (mg/l)	1258	1269	1314	1300	1278	1297	1267	1314
Nitrates (µg at/l)	1.39	1.27	1.34	1.42	1.36	1.34	1.31	1.36
Nitrites(µg at/L)	0.45	0.54	0.39	0.44	1.05	0.55	0.66	0.52
Chloride (g/l)	17.48	17.55	17.64	17.58	17.59	17.52	17.61	17.58
Oil & grease (mg/l)	0.33	0.27	0.35	0.34	0.41	0.39	0.35	0.41

Sediment properties. pH level was recorded from 7.94 to 8.03, with the highest level recorded in station 4 and the lowest level in station 2. (Table 8). Oil and grease level were between 0.37 and 0.44 mg/kg, with the highest level recorded in station 1 and the lowest level in station 2. Organic matter was between 2.522 and 3.147%, with which the lowest level was recorded in station 2 and the highest level in station 4.

Table 8: Physical and chemical properties of sediment

Sediment	Station 1	Station 2	Station 3	Station 4
pH	7.96	7.94	7.99	8.03
Oil & grease (mg/kg)	0.44	0.37	0.42	0.41
Organic matter (%)	2.654	2.522	2.741	3.147

4.3 Biological Environment

Biodiversity was studied around the proposed sub-project site (Kariyachalli Island) within a 5 km radius which also covers the nearby Vilanguchalli Island (Fig.11). A total of 8 major coral reef sites and 9 patch reef sites were identified and assessed. Out of the 8 major coral sites, 4 fall around Kariyachalli Island and 4 around Vilanguchalli Island. Patch reefs are found scattered within the 5 km radius of the sub-project site and of them, 4 fall closer to Kariyachalli Island and 5 closer to Vilanguchalli Island. Likewise, 17 seagrass sites were also identified within the 5 km radius of the sub-project site and of which 11 fall closer to Kariyachalli Island and 6 fall closer to Vilanguchalli Island.

Among the 4 coral sites in Kariyachalli Island, the live coral cover deviated between 31.10% and 35.41% while algae were the dominant benthic category which ranged between 29.06% and 40.36%. Coral massive was the dominant coral life form category distantly followed by coral foliose in this Island. *Acroopra, Montipora, Porites, Dipsastraea, Favites, Platygyra* and *Turbinaria* were the most common coral genera in this Island. The density of fish species among the coral sites of Kariyachalli ranged between 553 and 821 250m^{-2} with a total of 112 species and the commonly observed fish species were *Chaetodon octofasciatus, Scarus ghobban, Abudefduf vaigiensis* and *Abudefduf saxitalis.* Macrofaunal density in these sites ranged between 11.2 and 14.2 5m^{-2} with a total of 51 species dominated by *Holothuria scabra, Cypraea tigris, Trochus radiatus, Turbinella pyrum* and *Pentaceraster affinis*.

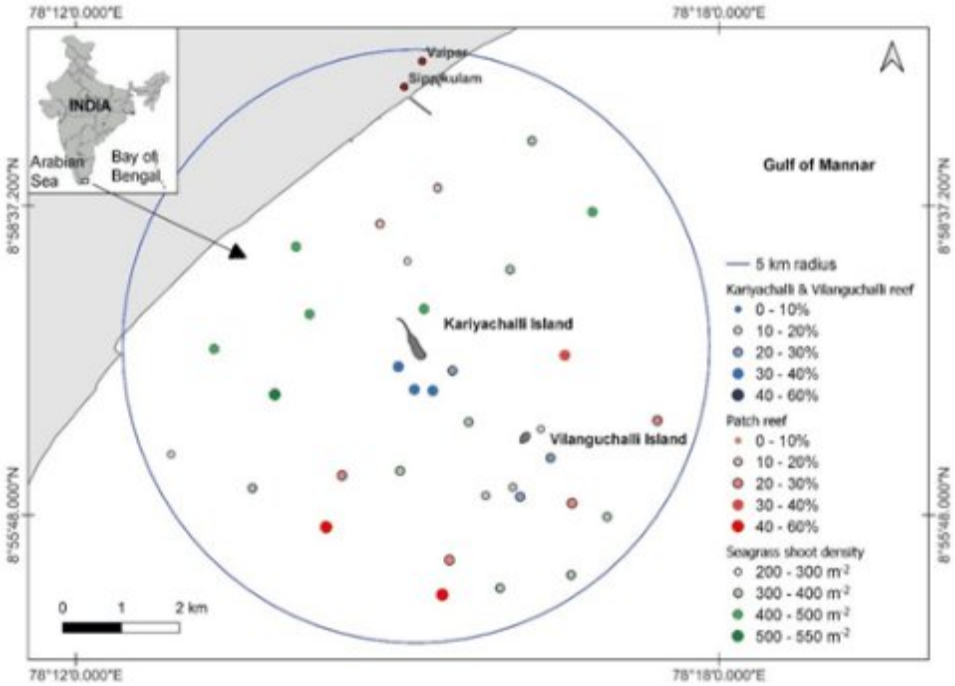


Figure 11: Marine resources study area (5 km radius) surrounding the sub-project **site**

Among the 4 coral sites in Vilanguchalli Island, live coral cover ranged between 14.28% and 23.74% where algae were the dominant benthic category ranging between 46.62% and 49.43%. Among the coral life form categories, coral massive was the dominant followed by Acropora branching. Among the available coral genera, *Acropra, Montipora, Porites, Dipsastraea, Favites, Platygyra* and *Turbinaria* were the common ones. A total of 33 coral

species were observed in Kariyachalli and Vilanguchalli Island during the study. In the coral sites of Vilanguchalli Island, the density of fish ranged between 359.3 and 504.1 250m^{-2} with a total of 102 species and *Chaetodon octofasciatus, Abudefduf saxitalis, Scarus ghobban* and *Lutjanus fulvus* being the common ones. The density of macrofauna was between 8.7 and 9.75m^2 with a total of 39 species and dominant species were *Holothuria atra, Cliona* sp*., Didemnum* sp*., Stichodactyla* sp*.* and *Turbinella rapa*.

Among the 9 patch reefs observed, the live coral cover deviated between 15.5% and 42.84% and abiotic and others were the dominant benthic categories as abiotic ranged between 3.16% and 43.06% and others ranged between 8.21% and 43.5%. Acropora branching was the dominant coral life form category among the patch reefs followed by coral massive and coral foliose. A total of 29 coral species were observed in patch reefs during the study. *Acropra, Dipsastraea, Favites* and *Turbinaria* were the common coral genera observed among the patch reefs. The density of fish ranged between 72.1 and 414.9 250m^{-2} among the patch reefs with a total of 70 species *and Scarus ghobban, Chaetodon octofaciatus, Siganus javus* and *Abudefduf saxitalis* were the common fish species. Macrofaunal density in the patch reefs ranged between 12.1 and 19.9 5m^{-2} with a total of 55 species and the common macrofaunal species were *Holothuria atra, Synapta, cliona* sp*. Colina* sp*. Gafrarium sp.* and *Turbinella pyrum*.

Among the 17 seagrass patches assessed within the 5km radius of the sub-project site, the seagrass cover ranged between 22.51% and 76.1%. The overall shoot density of seagrasses in these 17 seagrass patches ranged between 277.92 and 536.46 m^{-2}. *Cymodocea serrulata, Syringodium isoetifolium* and *Thalassia hemprichii* were the dominant seagrass species at the study sites as covers and shoot densities were the highest for these three species during the study. Among the seagrass sites, the fish density ranged between 82.3 and 226.5 250m-2 and a total of 20 species were observed. The most dominant fish species was *Terapon puta* with 249.8 250m^{-2} followed by *Lutjanus* sp. with 250m^{-2} and *Sphyraena obtusata* with 250m^{-2}. Macrofaunal density in the seagrass patches ranged between 4.1 and 11.7 5m^{-2} with a total of 30 species dominated by *Holothuria atra, Salmacis bicolor, Didemnum* sp*., Stichodactyla* sp*., Cliona* sp*., Lambis lambis* and *Canarium* sp. All the analyzed physico-chemical parameters were within the optimum levels and extreme levels were not observed. Phytoplankton density was observed between 275.36 and 300.24 cells/l and zooplankton density was between 1,96,584 and 2,13,451 no/m^3. No coliform bacteria were recorded in water and sediment samples at all study sites and heavy metal levels in samples were within the permissible limits.

4.4 Social Environment

Within the 10 km radius of Kariyachalli Island, there are three fishing villages namely Vaipar, Sippikulam and Pattinamaruthoor. Sippikulam is about 3.5 km away from the Island. Vaipar and Pattinaputhur are about 4 and 8 km respectively away from the Island. The present study included more villages that may be benefitted from the sub-project activities as the fishermen in these villages have long fishing connections with the project area. The sub-project activities like the deployment of ARs, and restoration of coral reefs and seagrasses will enhance the fish production in the sea, as they contribute to the spawning and breeding of

reef and inshore fishes which would benefit the fishing communities by way of increased fish catch. Fishermen will not be affected by the project activities. As the sub-project areas lies in the protected areas, they are not visiting the areas for the fishing.

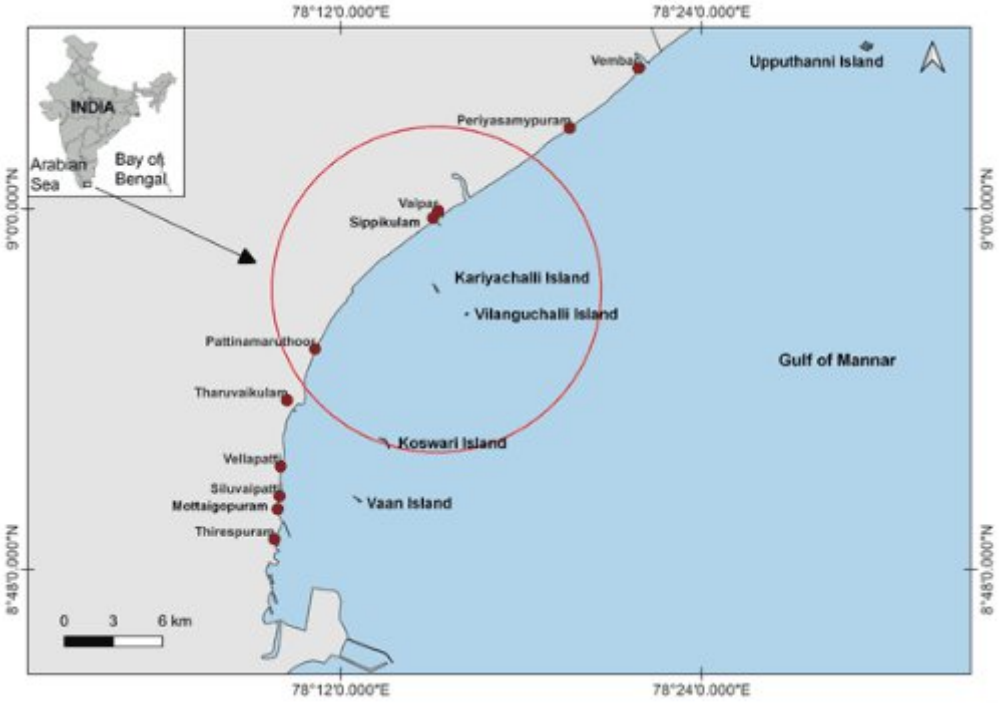


Figure 12: Map showing the location of sub-project villages

Totally 10 villages were considered for the present study, which include Thirespuram, Mottaigopuram (Thalamuthunagar), Siluvaippatti, Vellapatti, Tharuvaikulam, Pattinamaruthoor, Sippikulam, Vaipar, Periyasamipuram and Vembar. The social impact assessment in these villages was carried out using both primary and secondary data. Direct interviews with questionnaires were carried out among the coastal communities in the villages and secondary data were collected from published literature A total of 104 respondents were interviewed in these 10 villages which include both genders and different age groups between 15 and 80. A copy of the questionnaire is placed in **Annexure 4.**

4.4.1 Demography and socio-economic status

Majority of the fishermen of these villages depend on traditional fishing. They use motorized and non-motorized fishing boats for their livelihood. CMFRI has collected socio economic data in 2020 of all villages bordering Gulf of Mannar. Altogether 8,698 fisher families with a total population of 33,143 live along the coast in these ten villages. Almost 98% of fisher families in these villages are Below Poverty Line BPL The average sex ratio is 937 females per 1000 males for the 10 villages. The average family size is 4 in all the villages.(Table 10).

Table 9: Details of fishermen families and population

S No	Name of the village	Fishermen families	BPL families	Fisherfolk population
1	Thirespuram	3413	3303	12887
2	Mottaigopuram	600	599	2454
3	Siluvaipatti	1110	1110	4033
4	Vellapatti	325	325	1344
5	Tharuvaikulam	1451	1378	5495
6	Pattinamaruthoor	105	105	420
7	Sippikulam	163	163	652
8	Vaipar	525	525	1861
9	Periyasamipuram	363	363	1345
10	Vembar	643	638	2652
				33143

Source: CMFRI-DoF 2020 (Marine Fisheries Census 2016 - Tamil Nadu. Central Marine Fisheries Research Institute, Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare; Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India) (https://eprints.cmfri.org.in/17493/2/TAMIL%20NADU%20Marine%20Fisheries%20Census%20India%202016.pd)

Table 10 : Age-wise and sex-wise classification of fisher folk's population

S No	Name of the village	Male			Female			Total	Average Family Size	Sex Ratio (Females per 1000 male)
		Adult	Children		Adult	Children				
			Up to 5 yrs	Above 5 yrs		Up to 5 yrs	Above 5 yrs			
1	Thirespuram	4267	613	1638	4072	650	1647	12,887	4	977
2	Mottaigopuram	838	92	326	804	89	305	2,454	4	954
3	Siluvaipatti	1039	223	829	1071	176	695	4033	4	929
4	Vellapatti	422	62	210	424	85	141	1344	4	937
5	Tharuvaikulam	1832	253	743	1679	274	714	5495	4	943
6	Pattinamaruthoor	133	18	65	121	20	63	420	4	944
7	Sippikulam	254	32	55	218	32	61	652	4	912
8	Vaipar	637	102	224	607	63	228	1861	4	933
9	Periyasamipuram	357	32	321	337	38	260	1345	4	894
10	Vembar	603	83	678	613	98	577	2652	4	944

Source: CMFRI-DoF 2020 (refer Table 10)

4.4.2 Literacy and Education Status

Literacy and Educational status are important indicators of the socio-economic level of any society. All those who have completed primary school are considered literate and about 65% of the fisher folks in these villages are literate. Out of the total literates, 33% are males and 32% are females. Out of the total literates, 44% have completed education up to primary level, 45% up to higher secondary level, 6% have gone above the higher secondary level and another 6% have gone for graduation and above (**Table 11**)

Table 11: Educational status of fishers in Tuticorin region

S No	Name of the village	Educational details							
		Primary		Higher Secondary		Above Higher Secondary		Graduation and above	
		Male	Female	Male	Female	Male	Female	Male	Female
1	Thirespuram	1696	1509	1886	1861	149	186	240	294
2	Mottaigopuram	419	460	687	573	33	29	17	36
3	Siluvaipatti	343	367	135	140	44	58	40	50
4	Vellapatti	211	210	221	184	71	53	44	15
5	Tharuvaikulam	975	840	1171	1087	113	121	117	128
6	Pattinamaruthoor	57	65	93	78	9	0	6	7
7	Sippikulam	139	125	110	96	22	16	8	31
8	Vaipar	457	383	272	298	32	39	17	33
9	Periyasamipuram	411	375	173	137	50	64	9	6
10	Vembar	164	130	201	232	61	63	35	93

Source: CMFRI-DoF 2020 (refer Table 9)

4.4.3 Occupational Pattern and Employment Status

All the ten villages are predominantly fishing villages. Men are mostly engaged in active fishing while women are involved in allied activities. The key allied activities include marketing fish, making/repairing nets, curing/processing, peeling, labourers and others (**Table 12**). A total of 8,770 active fishermen are thriving in these villages out of the total of 11,681 employed people. A total of 1,367 people are involved in fishing allied activities and 544 people are involved in activities not related to fishing.

Among the ten villages, Thirespuram is one of the major fish landing areas with catch yield of about 13,94,785 kg in 2022 18,53,256 kg in 2023, followed by Tharuvaikulam with 13,85,486 kg in 2022 and 13,55,866 kg in 2023. Lowest fish landing was observed in Periyasamipuram with 71,521 kg in 2022 and 61,085 kg in 2023 (SDMRI Dataset). The major commercial landing areas of Thirespuram and Tharuvaikulam have a greater number of crafts and active fishermen among the ten villages. Fishing gears commonly operated in all the ten villages include trawl nets, hooks and long lines, gill nets, ½ no. nets, disco nets, shrimp nets, tuna nets, sardine nets, mackerel nets, etc. 83 species of fish were found caught in these villages of Tuticorin coast from 2022 to 2023. Some of the commonly caught commercially important fin fish and shell fish species include *Carangoides malabaricus, Caranx ignobilis, C. sexfasciatus, Sardinella longiceps,S. fimbriata, S.gibbosa, Hemirhamphus far, Lethrinus nebulosus, L. ornatus, Lutjanuslunulatus, L. fulviflamma, L. fulvus, L. johnii, L. russelli, Scarus niger, S. ghobban, Cephalopholis formosa, Epinephelus areolatus, E. coioides, Sphyraena, barracuda, Scomberomorus commerson, Portunus pelagicus, P. sanguinolentus,Charybdis feriata, Panulirus homarus*and *Turbinella pyrum.* Many of these fish are mostly habitat-dependent and are reliant on coral reef or seagrass ecosystems.

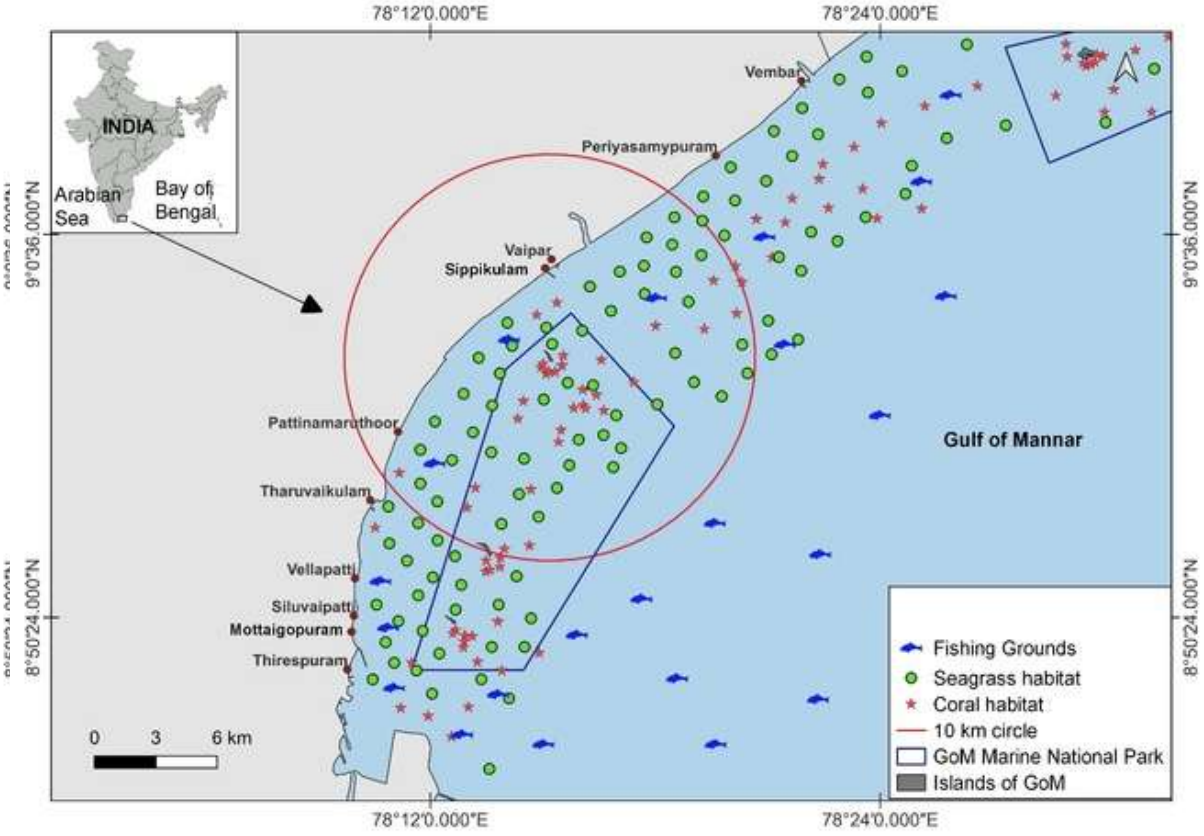
Table 12: Occupational pattern and employment status

S No	Name of the village	Active fishermen	No of members involved in fishing allied activities						Other than fishing	Total
			Marketing of fish	Making / Repairing net	Curing / Processing	Peeling	Labourer	Others		
1	Thirespuram	3643	184	3	79	105	12	70	114	4210
2	Mottaigopuram	322	235	4	81	155	72	52	161	1082
3	Siluvaipatti	1143	17	0	1	3	12	0	65	1241
4	Vellapatti	328	4	6	19	6	112	14	0	489
5	Tharuvaikulam	1559	28	98	1	4	5	41	0	1736
6	Pattinamaruthoor	110	0	5	0	0	0	0	3	118
7	Sippikulam	171	2	0	0	10	0	3	3	189
8	Vaipar	528	84	3	1	62	3	6	22	709
9	Periyasamipuram	362	3	238	0	37	12	0	52	704
10	Vembar	604	138	76	6	245	0	10	124	1203
	Total	**8770**	**695**	**433**	**188**	**627**	**228**	**196**	**544**	**11681**

Source: CMFRI-DoF 2020 (refer Table 9)

Most of the area within the 10 km radius of the sub-project site falls within the boundary of the Gulf of Mannar Marine National Park (GOMMNP), where commercial fishing is not allowed particularly 1 km around the Islands. However, there are fishing grounds that fall outside the boundary of the GOMMNP and within the 10 km radius (Figure 13). As this area is closer to the mainland, mechanized trawling does not happen in this area. All the fishermen who fish within the area are small-scale fishermen. These fishermen do fish about 1 km away from the coral reef, seagrass and sandy areas near the Sub-project site and the total number of legitimate fishing grounds within the 10 km radius of the sub-project site is 22. An additional 10 fishing grounds are found in the route of the barge transportation from Tuticorin Old Harbour. The proposed route for the barge to Island is shown in Figure 14. A total of 375 fishing crafts are being operated within the 10 km radius of the sub-project site and a total of 1,156 fishermen are involved in fishing here. Vaipar, Tharuvaikulam and Sippikulam are the villages that primarily use this area for fishing. Figure 15 shows the fishing tracks of different fishing crafts.

Figure 13: Fishing grounds and resource details around the sub-project area



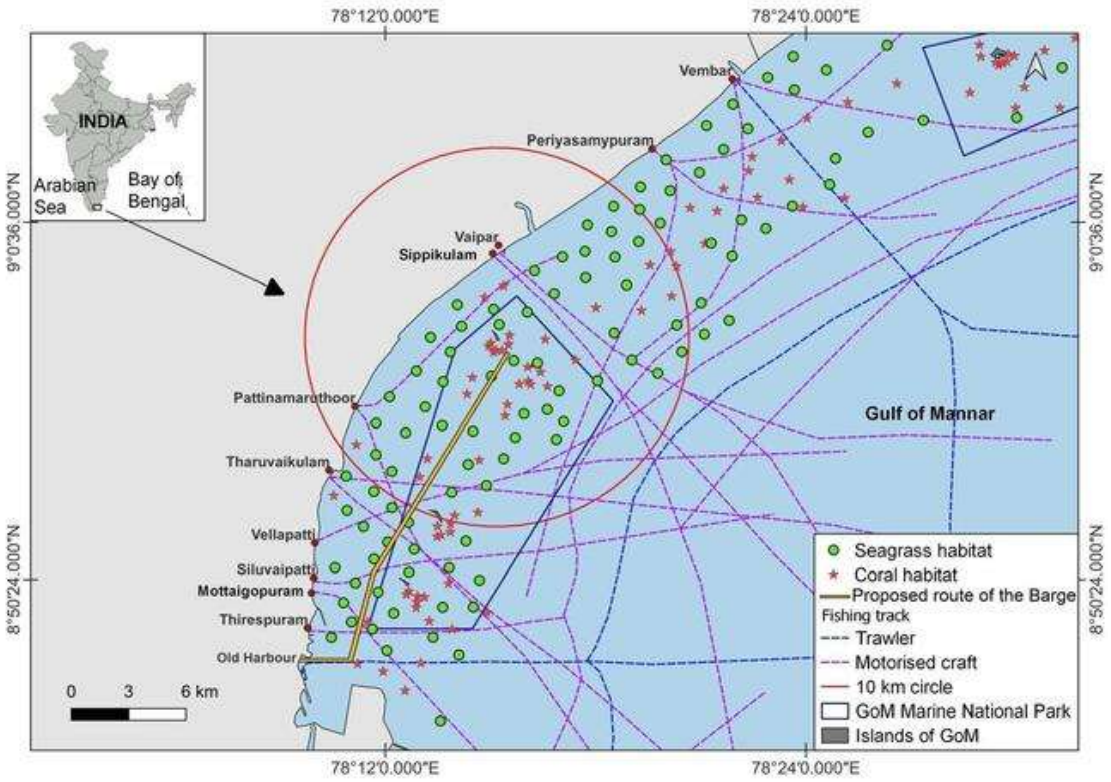


Figure 14. Proposed route of barge from Old harbour Tuticorin to the Island

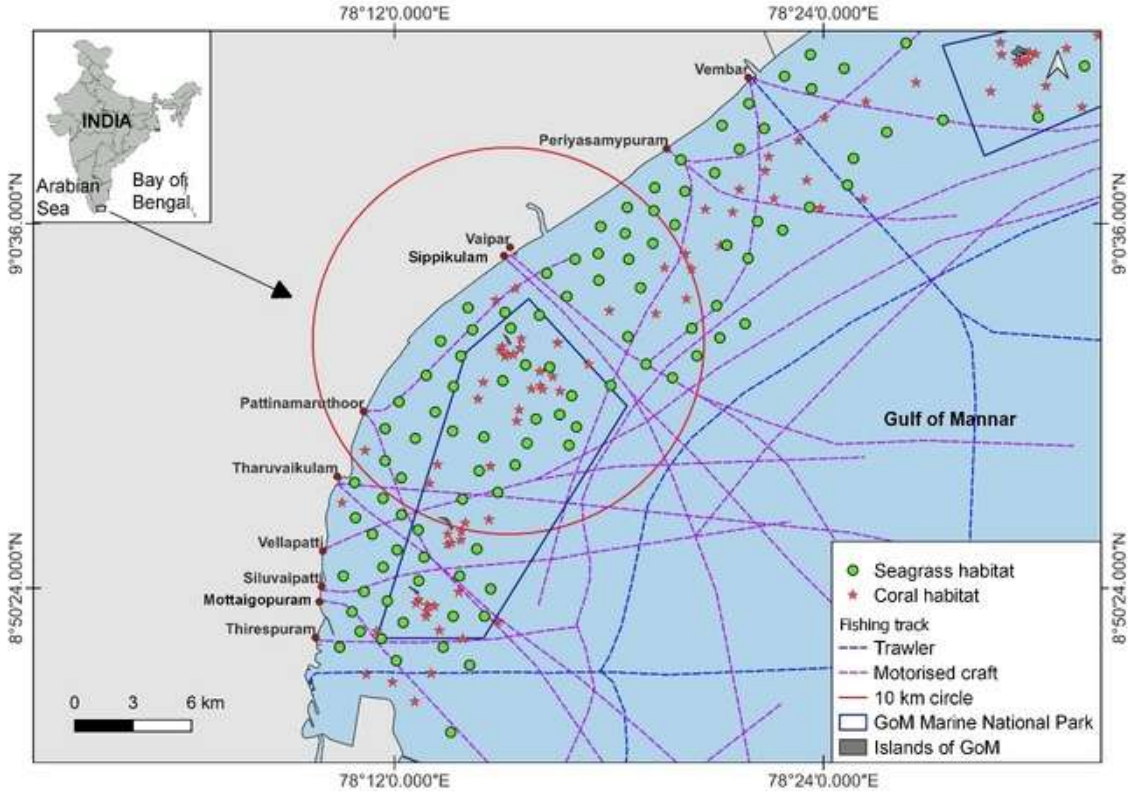


Figure 15: Fishing track of fishing crafts and resource details around the sub-project area

5. Potential Impacts and Mitigation Measures- Environmental and Social

5.1 Potential Environmental and Social Impacts

Deployment of Artificial reef modules shall bring in only positive environmental and socio-economic benefits.

5.1.1 Potential environmental benefits include:

- Improvement of the biological characteristics of the reef on site/surrounding seabed and the faunal communities;
- The diversion of subsistence or commercial fishing pressure away from sensitive natural ecosystems;
- Protection of vulnerable ecosystems from destructive/illegal fishing techniques;
- Reduction of some of the impacts of, for example, caged fish aquaculture, by absorption of excess organic matter and thereby improvement of water quality;
- Compensation for habitat loss elsewhere;
- Re-establishment of biological communities after, for example, a cyclone or pollution incident.

5.1.2 Potential socio-economic benefits include:

- Increased marine/fisheries resources availability leading to improved food security and standard of living for local people;
- Enhancement and/or protection of local/coastal fisheries;
- Improved fishing conditions for local fishermen (security of the harvest, locations closer to the coast, etc.);
- Improvements in recreational opportunities, such as fishing and diving, which may lead to tourist attraction;
- Enhancement of stocks through habitat creation;
- New or enhanced opportunities for aquaculture developments;
- Enhanced supply of fisheries resources; and
- Research and educational opportunities

The fishing resource Survey is proposed in Table 19, 20 and 21. The baseline data will be created before start of the work as per table 19. Thereafter, the baseline will be updated. So, there will be baseline data for the potential increase in the fishing resources.

The ecotourism operation is handled by the forest department with involvement of the community through Eco-development committees (EDCs). Only at identified, tourists will be allowed. Ecotourism is well managed, controlled and coordinated activity. So, the problem of overrun by tourist will not arise.

Impact of the Ecodevelopment Activities

(a) It will help in creating new employment
(b) The community will get the micro credit support through the Eco-development Committees (EDCs)
(c) The capacity building program will help local youth to enhance their skills
(d) Local youth will be trained for diving and associated activities which will enhance their employability.

5.2 Impacts due to Deployment of Artificial Reef Modules

5.2.1 Impacts of Artificial modules in the sea and on neighbouring Island due to Deployment of Artificial Reefs

The AR modules used for erosion control are subject to corrosion inside the sea due to corrosive nature of seawater. Due to use of high quality materials (ISI certified) the materials weather very slowly and may cause pollution but at insignificant levels. During deployment, the water column becomes turbid and increases the turbidity in the vicinity for a day or two and this may affect the pelagic flora and fauna for a short period.

The AR modules of 20m width, and 850m length will be placed continuously along the 3 to 4 m contour at the southeast of the Island. The design of AR modules and the location to be placed had arrived after performing wave modelling. After the planning of the proposed layout, the possible effect on the neighbouring islands such as the Koswari and Vaan islands. The distance between Vaan and Koswari islands is about 4 km and the disturbance due to the neighbourhood was observed to be much less from the wave scattering diagrams. Further, the distance between the Kariyachalli and Koswari Island is about 10 km. Hence, the propagation simulation did not show any significant variation with the influence of neighbourhood islands. With this confidence, it is stated that the proposed intervention of the artificial reef south of Kariachalli Island would not affect Koswari and Vaan Islands. A detailed report in this regard is placed in **Annexure5.**

5.2.2 Land based impacts

Barren/empty land (preferably government land) far from the human habitation or rented land from private landowners, will be temporarily used for the construction of AR modules. Hence there will be no land acquisition or economic displacement. However, temporary noise impacts are anticipated during the construction works, especially during the transportation of construction materials.

5.2.3. Impact on Water Quality

The placement of ARs, using the methods described in Section 2.1, is unlikely to cause any significant impact on water quality during deployment. Disturbance of the seabed, causing a slight increase in turbidity and suspended solids, will occur during the placement of ARs. This, however, will be very localized and restricted to the immediate vicinity of the ARs and very transient in duration. . For the transportation of AR modules, properly maintained mechanised barge will be involved and a crane will be used for the lifting. Similarly trained/ skilled divers will be used during the AR module deployment stages and hence, the site will not be significantly populous to cause impact on water quality. The overall water quality impact is therefore insignificant.

Materials selected for the building of ARs will not leach any harmful substance into the environment causing adverse impact. If boats are used, they will be prepared to remove as far as possible any objectionable matters on board, such as oil and grease, following the mitigation measures described in Chapter 7. The impact of any residual oil and grease on water quality will be transient.

5.2.4. Impact on Noise Quality

No noise sensitive receivers are identified within 5km from the Kariyachalli Island (AR deployment sites). Works at the sites will not involve construction or percussive piling. The only noise generated will be those from a single mechanical derrick crane or grab used by the barge during deployment of the ARs. Noise levels during working hours will not exceed 55 dB stipulated by CPCB (https://cpcb.nic.in/who-guidelines-for-noise-quality/) . Impact on noise quality is expected to be minimal during deployment of the ARs. As there is a maximum of only two trips per day, the noise generated by the vessel will be limited to a minimum period. Similarly, no major noise creating equipment will be involved for deployment and only the derrick crane will be used. The noise created by the crane will be less and will not affect the fish movement in the nearby area.

5.2.5. Impact on Marine Traffic and Navigation

The proposed AR deployment area does not lie in any major marine traffic or navigation channels. All deployed ARs will have a minimum clearance depth of 9m and will not affect the small fishing boats/fibre glass boats in the area. As soon as deployment is completed the depth at which the AR modules deployed will be shared with the fishing communities through the Forest department, which will help fishermen navigate that area. In case artisanal fishermen use deploying nets nearby the route, it may temporarily affect their livelihood, in case they do not find an alternate fishing area.

5.2.6. Impact on coral reefs

The neighbourhood of the proposed sub-project site is richly provided with coral reefs and associated biodiversity as the area falls within the boundary of the GOMMP. It will be made sure that the AR modules will not be deployed in reef areas. Not a single colony of coral will be put to mechanical damage such as uprooting, breaking, or crushing. Hence, there will be no impact on corals due to the project activities. As per the context of the project, the proposed sub-project activities such as the deployment of AR modules and coral restoration would significantly increase the coral cover in the area within a few years. AR modules deployed around the Island will provide substratum to thousands of newly settling coral recruits as evidenced from the experience in Vaan Island. Coral restoration has also been proposed in the present sub-project by which coral biomass can be increased in the project area using fast growing coral species. Thus, there is no potential negative impact on coral reefs in the sub-project site and in its vicinity while the activities carry plenty of positive impacts to the coral reefs. The restored reef areas and AR modules with coral recruits will look similar to a natural reef within five years. As the sub-project p is positively impacting the coral reefs, the reef associated biodiversity will be benefited significantly due to the sub-project activities.

5.2.7 Impact on seagrasses

The AR modules will be deployed on the seaward side of the Kariyachalli Island and seagrasses in the seaward sides of the islands are comparatively very low in abundance. The AR modules will be deployed in clusters in the sandy areas. Hence, there is very little chance of them affecting seagrass beds. However, there may be small seagrass patches underneath the deployment areas which may be affected during the AR deployment. This will be a very minimal impact and the same should be compensated by the wide-scale seagrass restoration

proposed in the project. Three acres of degraded seagrass areas are proposed to be restored during the sub-project. The survival and growth of restored seagrass beds in the Gulf of Mannar have been very high. Within two years of restoration, the restored seagrass areas will act similar to that of a natural seagrass area. The provision of biodiversity support and carbon sequestration will be similar to that of a natural seagrass area. Thus, the sub-project activities will not negatively affect the seagrass beds in the vicinity, but a significant positive impact is on the cards.

5.2.8 Impact on fishery resources

Generally, AR modules are deployed to enhance fish diversity and density. Though the primary objective of this sun-project is to protect the Island from erosion, the enhancement of fish abundance will be obvious. There is no chance of any negative impact on fishery resources due to the project activities. As observed in the Vaan Island (where AR modules were deployed to control erosion) Fish are expected to come and inhabit AR modules within a day after the deployment as they find shelter in and around the modules. As the AR modules are deployed in clusters, the fish will have plenty of sheltered space to grow and reproduce. Fish spawning aggregation is very much possible in and around the AR modules. During coral bleaching seasons, reef fish generally migrate to deeper reef regions due to the lack of reef complexity. However, the AR modules provide the fish much needed complexity and hence they will not migrate to deeper waters. Further, coral restoration and seagrass restoration proposed in the project would enhance the associated fish abundance. The increase of biomass of corals and seagrasses over the years due to restoration activities would harbour more fish.

5.2.9 Impact on fishing activities

The proposed project site and its vicinity fall within the GOMMNP where fishing is prohibited. The prohibited zone for Tuticorin group of Islands is approx. 118 sq.km (Fig.16). This area is based on notification CG-DL-E-07012020-215191, dated 1st January, 2020) issued by the Ministry of Environment, Forests and Climate Change. Fishermen use the fishing grounds on the periphery of the boundary of the GOMMNP where there is no intended project activity. (Fig 16). The fishermen fish beyond this zone. The AR modules are transported from the nearest shore in Tuticorin preferably from the Old Harbour to Kariyachalli Island which is a regular route for all fishing crafts. In case, the artisanal fishermen deploy the net near the route, it may affect their fishing.

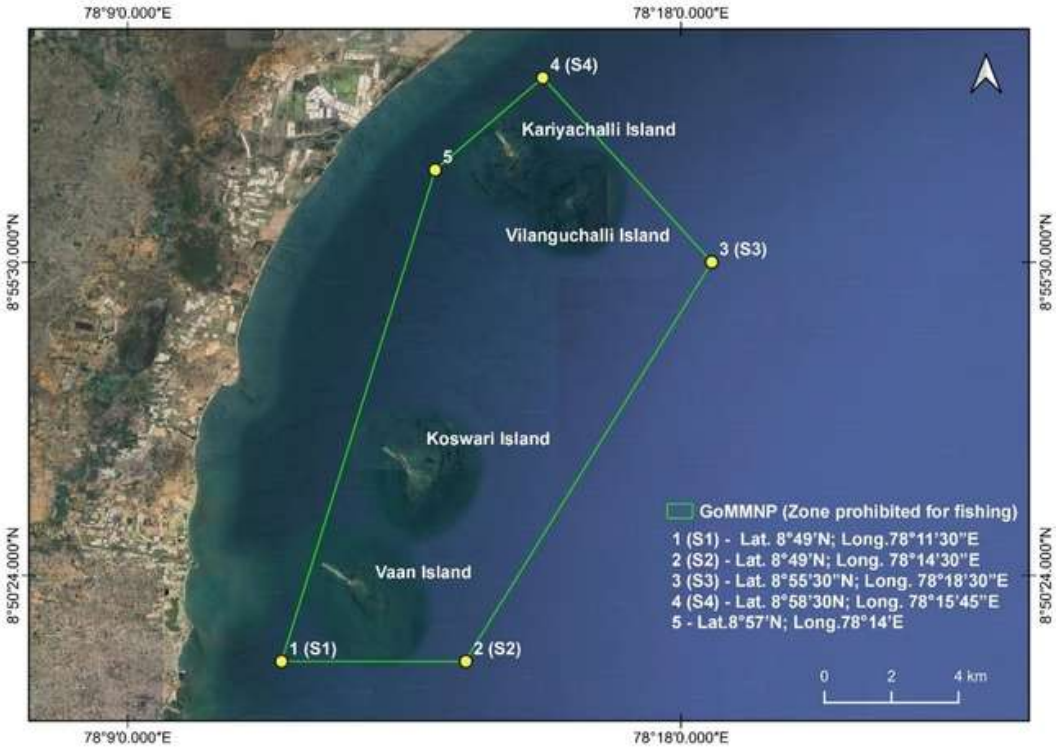


Figure 16: Fishing prohibited zone in Tuticorin group of Islands in the Gulf of Mannar

5.2.10 Impact on benthic organisms

Usually, when loading materials onto the barge, there is a possibility of spilling of waste material into the sea. This could affect the water quality, which can impact both benthic and pelagic biota and would consequently affect the fishery resources. But in the present project, constructed and properly cured artificial reef modules are going to be loaded in the barge, so there is no possibility of the creation of dust waste and spilling of materials into the sea. Each day, there will be two trips depending on the weather conditions. So, the possibility of the formation of dust waste and the spilling of waste materials into the sea is negligible.

During the course of the navigation, towing vessel, fuel leakage and oil spill from the towing vessel, and leaching of antifouling paints. This could affect the environment and could be taken by current into the nearby fishing ground. As far as the present proposed project is concerned, the possibility of the creation of dust waste and spilling of waste material during the course of transportation is negligible. Only one properly maintained mechanised vessel with a barge will be involved. So, it would not affect the environmental quality on the course of the navigation route. There will be two trips of transportation of artificial reef modules to the deployment in a day. Similarly, during deployment in the proposed site, scientific professional divers with expertise in coastal habitats (Coral and Seagrass beds) will be employed for alignment, and orientation to maximize habitat complexity and colonization potential and to minimize disturbance to the bottom habitats. Hence this will reduce the impact on the bottom habitats.

8500 AR modules proposed to be deployed will occupy 34000 sq. m of the seabed (size of each module H1xL1Xb 4 m) which reveals that benthic fauna (Echinoderms, molluscs, sponges, etc.) inhabiting the sea floor area will be partially masked and there will be permanent loss of the fauna in this zone. However, as the AR modules themselves form a substrate, especially for sessile organisms, there is a possibility that new colonies of benthic fauna will appear over time to compensate for the loss. Further, if any settlement of non-native species of algae and other organisms is observed, they will be removed mechanically during monitoring periods.

5.2.11 Impact due to loading and unloading of artificial reef modules

Skilled and semi-skilled workers will be employed during loading of artificial reef modules onto the barge, during transportation, and during unloading of artificial reef modules in the deployment site. During the AR module deployment, there is risk to the divers who will be under the water while arranging the modules in proper order .. Safety protocols and risk management measures will be prioritized to ensure the well-being of scientific professional divers with expertise in coastal habitats (Coral and Seagrass beds) and other personnel involved in the artificial reef deployment operation. Comprehensive safety briefings, equipment checks, and emergency response drills will be conducted to mitigate potential hazards and address unforeseen challenges during deployment activities.

5.2.12 Other Impacts and Considerations

No impact on air quality or other considerations, such as hazards, waste, landscape and cultural heritage, are and envisaged in the implementation of this project.

5.2.13 Sub-project benefit to fishing communities

The sub-project activities will enhance the adaptive capacity of the coastal community so that they can have sustained livelihood and food security. Deployment of artificial reef modules will reduce the erosion of Kariyachalli Island and protect it from submergence and thus ensure the long-term ecological benefits offered by it including protecting the coasts of the villages. Protection of the Island ensures the protection of adjacent mainland from erosion and other natural calamities such as tsunami. Lives and properties of the nearby coastal villages will be protected as long as the Island is intact. Moreover, the Island itself will be protected by sub-project activities and the Island will continue to protect the lives of fishermen during rough weather seasons.

Artificial reef modules will expand and enlarge the sources for fish aggregation and production and thereby ensuring livelihood security and strengthening the adaptive capacity of the coastal communities. Fish production will help build livelihood sustainability for the benefit of small-scale fishers through incremental fish catch, and to maintain ecological balance. The AR modules also facilitate the fish populations and other biodiversity in adapting themselves against the climate change variations. They help not only to reduce migration of fish during elevated SST, but also to increase the fish production. Therefore, the low-income, small-scale fishermen depending on coral resources for their fishery are benefitted through sustained fish catch and livelihood.

Coral rehabilitation carried out in the project will help in saving and protecting the corals by increasing the coral biomass and thus ensuring their long-term sustainability. Seagrass rehabilitation will increase the seagrass cover and associated fishery resources for long-term sustainability for the fishermen. The restoration of coral reef and seagrass ecosystems would continue to increase as many of the ecosystem services would rejuvenate the region after a few years when the corals have fully grown. The intangible benefits of the project would be higher than the tangible benefits. The steps in the project implementation such as deployment of AR modules, deployment of coral restoration substrates and transplantation of seagrass will be carried out with the involvement of fishermen enlisted from the local communities. They will be trained appropriately on the technical knowhow as well as the benefits. The youth would not only benefit from the additional income received as daily wages, but also get their skill sets enhanced in the process. It will be made sure that among the workers involved none of the youth will be less than 18 years of age.

The eco development activities will include capacity building (to train 1800 women and 40 men) on alternate livelihood options, such as micro credit, revolving fund, petty shop management etc., and gender empowerment through the increase of fishery resources for the ongoing supplementary income generation activities like pickling and strengthening of village institutions to manage the ecosystem even after the sub-project period ends. These schemes have been under monitoring for the past few years to check whether they cause any negative impact on fishing communities. The observations made indicated no negative impacts.

5.2A Potential impact due to Eco-developmental Activities

Table: 12A Potential impact due to Eco-developmental Activities

Sr. No.	Proposed activities	Potential Negative Impact	Potential Positive Impacts
1	SHG related activities, which will include areas such as micro-credit provision, revolving funds, SHGs nurturing wherein alternate livelihood opportunities will be generated for the communities.	No negative impact from these activities. Gulf of Mannar Biosphere Reserve Trust is	i. Enhance the Skills of local community. ii. Employment Generation i. Sustainable livelihood generation
2	Conservation of marine ecosystem through	No Potential negative impact	i. Increased awareness about marine biodiversity

	awareness creation for SHGs		ii. Increased community efforts in terms of wildlife rescue
3	Reviving and nurturing SHGs	No Potential negative impact	Reviving and nurturing SHGs revitalizes community engagement, strengthens support networks, and provides access to micro-credit and revolving funds, promoting entrepreneurship and financial stability.
4	Extending SHG loans to fishermen	No Potential negative impact	Extending SHG loans to fishermen provides affordable capital for upgrading equipment, adopting sustainable practices, and diversifying income. This reduces dependence on high-interest lenders, improves financial stability, supports marine conservation, and enhances fishermen's livelihoods. The resulting financial security also benefits their families' health, education, and well-being.
5	Construction of community hall, training facility and fish auction facility	Construction debris might cause marine pollution.	i. Enhance access of better facilities for fisherfolk
6	Imparting specific local skill upgradation training to fisherwomen SHG members (i.e. tailoring, embroidery, etc.)	No Potential negative impact	i. The capacity building ii. Increased employability iii. Increased income and thus decrease in poverty
7	Imparting vocational training to fisher folk youth	No Potential negative impact	i. The capacity building ii. Increased employability iii. Increased income and thus decrease in poverty
8	Biodiversity and SCUBA diving training	No Potential negative impact	Biodiversity and SCUBA diving training positively impacts environmental conservation and local livelihoods by equipping participants with skills to explore marine

			ecosystems. Certified divers can engage in eco-tourism activities, generating income and promoting awareness of marine conservation. They can also participate in conservation efforts like reef monitoring and clean-up activities, empowering communities to become stewards of their natural environment and ensuring the sustainability of marine resources for future generations.
9	Eco tourism and construction of interpretation-cum-training centre to carry out dissemination of information regarding GoM.	It might cause the disturbance to the Turtle habitat. So, shall be planned carefully. It might affect the routine fishing routes. So, the planning of ecotourism shall be done with participation of the local community.	The establishment of an eco-tourism initiative and an interpretation-cum-training center can enhance community engagement and environmental education about the Gulf of Mannar (GoM). This center will disseminate information on local biodiversity and conservation, fostering appreciation for marine ecosystems. It will generate income and create job opportunities in hospitality and guiding services while providing training programs that empower locals to participate in eco-friendly tourism and conservation efforts.
10	Marine ornamental fish breeding with Clown Fish, Sea Bass, etc.	There might be disturbance to the local native species. So, there shall be strict control on it. Exotic species will not be allowed. Moreover, there will be onshore ornamental culture without	Marine ornamental fish breeding, particularly with species like Clown Fish and Sea Bass, helps reduce pressure on wild populations, preserving marine biodiversity and protecting fragile ecosystems. This initiative creates economic opportunities for local fishers and entrepreneurs by allowing them to sell ornamental fish, diversifying their income sources. Additionally, it promotes sustainable aquaculture practices, fostering environmental

		any contact with marine Environment. It will be ensured through 'Monitoring plan proposed under table 12 B'.	stewardship and awareness within the community. Overall, it contributes to conservation efforts while enhancing livelihoods through sustainable practices.
11	Cage fish culture	Potential disturbance to local ecology. So, no exotic will be allowed. It will be ensured through 'Monitoring plan proposed under table 12 B'.	Cage fish culture promotes sustainable aquaculture and enhances local food security by allowing controlled fish farming in natural water bodies, reducing overfishing and habitat destruction. It provides a reliable source of protein, improving nutrition and food availability while generating income for fishers and small-scale farmers, stimulating local economies. Additionally, this practice encourages sustainable farming techniques and fosters responsible resource management within the community.

Table 12B Mitigation plan or monitoring plan for the Ecodevelopment activities

S. No	Components	Parameters to be Monitored	Monitoring frequency
1	Construction of community hall, training facility and fish auction facility	Construction waste disposal	**Seasonal**
2.	Eco tourism and construction of interpretation-cum-training centre to carry out dissemination of information regarding GoM.	Site Location and fishing routes distance, No of community meeting about the operation of the ecotourism, Distance of Turtle nesting site/ Hatcheries from the ecotourism sites.	**Once in a year**
3.	Marine ornamental fish breeding with Clown Fish, Sea Bass, etc.	The species of ornamental fishes, Distance from the Coastal region(High Tide Line)	**Seasonal**
4.	Cage fish culture	The species of cultured in the cage culture	**Seasonal**

5.3. Applicable Environmental and Social Standards and their descriptions

The proposed activities were evaluated with Environmental and Social Standards (ESS) prescribed by the World Bank and the details are given in Table 13.

Table 13. Environmental and Social Standards

Environmental and Social Standards	Relevancy with Reasons
ESS 1: Assessment and Management of Environmental and Social Risks and Impacts	**Relevant**: Interventions are within fragile ecosystems (marine protected areas) and CRZ IV A, involving the transplantation of foreign materials (AR modules) and potential disturbance to existing habitats.
ESS 2: Labour and Working Conditions	**Relevant**: Activities require skilled labor and divers for the deployment of AR modules, and materials for coral and seagrass rehabilitation
ESS 3: Resource Efficiency, Pollution Prevention and Management	**Relevant**: The deployment of artificial substrates may cause localized turbidity.
ESS 4: Community Health and Safety	Relevant: Activities are confined to seawater. Land based activities like fabrication of AR modules will have low noise and dust levels and likely to affect the community living closeby.
ESS 5: Land Acquisition, Restrictions on Land use and Involuntary Resettlement	**Relevant**: The sub-project site is situated within seawater, with no land acquisition involved. The waters around the Island up to 10m depth are prohibited for fishing. Further the navigational routes of fishing boats are away from the Islands, and it does not affect the movement of fishing boats. Barren/empty land far (government land only) from the human habitation will be temporarily used for the construction/storage of AR modules, or rented from private land owners) if necessary. No private land will be taken for this purpose. Hence there will be no land acquisition or economic displacement
ESS 6: Biodiversity conservation and Sustainable Management of Living Natural resources	**Relevant**: Activities are located within CRZ IV A fragile ecosystems. Deployment of AR modules will mask seabed partially leading to permanent loss of biodiversity in this zone.
ESS 7: Indigenous Peoples/ Sub-Saharan African Historically Underserved Tradition Local Communities	Not Relevant
ESS 8: Cultural Heritage	Not Relevant
ESS 9: Financial Intermediaries	Not Relevant
ESS 10: Stakeholder Engagement and Information Disclosure	**Relevant**: Engagement with stakeholders and information disclosure is integral to the sub-project.

A separate exercise was carried out to evaluate the environmental and social impacts using a screening format and this sub-project shall be classified as "**Substantial Risk**" for the environment and "**Low Risk**" for social categories. Details on environmental and social screening carried out for AR module deployment and coral and seagrass restorations are given in **Annexure 6**. Detailed descriptions of the risks and impacts of relevant ESS are provided below:

5.3.1. E & S Risks and Impacts for ESS 1

The project activities like the deployment of Artificial Reefs (AR) Modules and coral reef restoration involve the use of concrete/cement structures which are foreign materials. During their deployment in the sea, the water column becomes turbid and affects temporarily the productivity of phytoplankton and the larval stages of animals. The number of artificial reef modules around the Island would be 8500 and the cement quadrats estimated to be a minimum of 40 sq. m per cluster of restoration area. The estimated blanketing of the sea bottom due to deployment of these structures will be around 40000 sq. m which leads to loss of habitat space in that area.

5.3.2. Risks and Impacts for ESS 2

The construction of AR modules for erosion control and fabrication of concrete frames and slabs for coral reef restoration requires the engagement of skilled and semi-skilled labour. During their construction, there are possibilities of injuries to the labour. This can also happen while loading in trucks to be placed in the barges and deployment in the sea using cranes. Besides labour, there are expert divers including scientific divers who guide the professional divers in seating the modules on the seabed in the pre-planned alignments. While deploying the modules there are possibilities of injuries to them underwater. Their life could be in danger if the diving equipment fails. Besides OHS risks, there could be risks relating to non-payment of wages, discrimination, unclear terms of employment, etc.

Mitigation: Following safety norms during construction, handling of concrete structures while loading and deployment and also thorough checking of diving equipment for their fitness to be used for diving in the sea (refer ESMP Table 16).

5.3.3. Risks and Impacts for ESS 3

The AR modules used for erosion control and concrete frames used for coral reef restoration are subject to corrosion inside the sea. Due to use of high quality materials (ISI certified), the materials weather very slowly and may cause pollution but at insignificant levels. During deployment, the water column becomes turbid and increases the turbidity in the vicinity for a day or two and this may affect the pelagic flora and fauna for a short period. Further, the plastic used for fabricating the quadrats for seagrass restoration also contributes to plastic pollution in the sea. While fabricating the concrete structures and PVC frames on the mainland, solid waste pollution also occurs.

5.3.4. Risks and Assessment for ESS 4

The risks involved while fabricating the AR modules include noise and traffic from vehicles carrying materials like blue metal to the construction site and dust created while unloading these materials. The dust may cause temporary suspended solid pollution in the air which disappears within 20 min or so. While cutting the steel rods required for reinforcing the concrete, noise will be generated. Both the activities, though the impacts are short-term in nature, may affect the community living close to the fabrication site

Mitigation measures: While the noise arising from trucks will be at par with normal trucks, the dust arising due to the unloading of blue metal needs to be dealt with by spraying water on blue metal while unloading. This will minimise dust pollution. Regarding noise arising due to cutting rods, the contractor will be advised to carry out the activity within the fabrication premises and far from the road.

5.3.5. Risks and Impacts for ESS 6

The seabed around the Island including in the area's projects is inhabited by benthic fauna like molluscs, echinoderms, sponges and other sessile and sedentary organisms. These organisms contribute to the richness of biomass and biodiversity of the area. The activities relating to deployment of AR modules and concrete structures almost blanket 40,000 sq. m of seabed area leading to the total loss of these organisms. Considering the presence of an average benthic faunal population density of 14 sq. m in an area of 20 sq. m (Reference ESIA document data), the loss of habitat area of benthic organisms would be approximately 28000 sq. m. This loss is substantial. Further, during seagrass plantation, there will be a marginal disturbance to the healthy habitats.

Mitigation/remedial measures

Though there are no mitigation measures to prevent the loss of benthic organisms, the AR modules themselves act as a substrate for the settlement of sedimentary and sessile organisms including molluscs and sponges which may over the years, compensate for the loss of benthic organisms.

5.3.6. Risks and Impacts for ESS 10

The main stakeholders are the fishing communities living in three villages (Sipikulam, Vaipar and Tharuvaikulam) on the mainland and close to the Island. There are 7 other villagers whose fishing vessels navigate through the Island. These villagers fish a km away from the Island as before this is a prohibited zone. These villages support the project activities and the project would benefit them, as the artificial reefs provide shelter to the fish and also form spawning and nursery grounds for the inshore fish. The only negative aspect is a disturbance/damage to the fishing nets due to the movement of barges that carry AR modules, concrete frames, slabs and PVC frames. Such aspects will need to be conveyed to all these stakeholders during the execution stage as well. Recent consultation held in June 2024 with the representatives of fishing communities from 7 villages gave an impression that the fishing has well understood the sub-project activities including the likely damage of fish nets if deployed close to the Islands and also along the navigational routes. A GRM mechanism is already part of the sub-project and necessary information about the GRM will be provided to the 10 villagers so that if there are any grievances, the fishing communities can express them to the sub-project authorities.

Mitigation/preventive measures

The 10 villages will be informed sufficiently in advance about the movement of barges for the deployment of structures so that the villagers can deploy the nets at a safe distance. Some of the fishermen may not like the sub-project activities due to a lack of understanding of the benefits and hence giving them the sense of ownership will help achieve the sub-project activities. Hence, local knowledge from the fishermen will be obtained in order to sail the sub-project activities smoothly. Knowledge obtained from them on water currents, their fishing grounds, fishing routes, fishing timings, etc. will be seriously considered while transporting the AR modules. Moreover, members from the fishermen community (including women) will be

used in activities such as coral rehabilitation and seagrass rehabilitation. Assistance from fishermen societies, Tamil Nadu Fisheries Department, Tamil Nadu Forest Department, NGOs and other stakeholders will also be used as and when needed. Awareness creation programs will be held in fishing villages in the regional language to make the fishermen and other stakeholders understand the importance of the sub-project activities.

5.4. Conclusion

The project has a holistic approach that strengthens the environment thereby providing long-lasting benefits to the society. The project activities will enhance the adaptive capacity of the coastal community so that they can have sustained livelihood and food security. The protection of Kariyachalli Island through the deployment of multipurpose Artificial Reefs (ARs) would benefit the environment and society in the following ways:

(i) Coastal erosion will be reduced in the nearby coastal area;
(ii) The integrity of the island ecosystem is maintained with rich coral reefs, seagrass beds and related biodiversity;
(iii) The increase in the area cover of the island would protect the mainland from wave action by defending the coast against rough climate conditions;
(iv) The increase in fish production will benefit the traditional small scale fisher folk with sustained livelihood.

5.4.1. Benefits to Coral Reefs

As per the context of the project, the proposed project activities such as the deployment of AR modules and coral restoration would significantly increase the coral cover in the area within a few years. A similar project on the nearby Vaan Island has helped enhance the coral cover significantly at the project site. Coral restoration has also been proposed in the present project by which coral biomass can be increased in the project area using fast growing coral species. The restored reef areas and AR modules with coral recruits will look similar to a natural reef within five years. As the project is positively impacting the coral reefs, the reef associated biodiversity will be benefited significantly due to the project activities.

5.4.2. Benefits to seagrasses

Three acres of degraded seagrass areas will be restored during the project. The survival and growth of restored seagrass beds in the Gulf of Mannar have been very high. Within two years of restoration, the restored seagrass areas will act similar to that of a natural seagrass area. Provision of biodiversity support and carbon sequestration will be similar to that of a natural seagrass area. Thus, the project activities will significantly strengthen the seagrass beds and associated biodiversity of the Gulf of Mannar.

5.4.3. Benefits on fishery resources

Generally, AR modules are deployed to enhance fish diversity and density. Though the primary objective of this project is to protect the Island from erosion, the enhancement of fish abundance will be obvious. Fish will come and inhabit AR modules within a day after the deployment. As the AR modules are deployed in clusters, the fish will have plenty of sheltered space to grow and reproduce. Fish spawning aggregation is very much possible in and around the AR modules. During coral bleaching seasons, reef fish generally migrate to deeper reef

regions due to the lack of reef complexity. However, the AR modules provide the fish much needed complexity and hence they will not migrate to deeper waters. Further, coral restoration and seagrass restoration proposed in the project would enhance the associated fish abundance. The increase of biomass of corals and seagrasses over the years due to restoration activities would harbour more fish.

5.4.4. Benefits to the society

Deployment of artificial reef modules will reduce the erosion of Kariyachalli Island and protect it from submergence and thus ensure the long-term ecological benefits offered by it including coastal protection to the coastal villages. Protection of the Island ensures the protection of the adjacent mainland from erosion and other natural calamities such as tsunamis. The lives and properties of the nearby coastal villages will be protected as long as the Island is intact. Moreover, the Island itself will be protected by project activities and the Island will continue to protect the lives of fishermen during rough weather seasons.

6. Stakeholder Consultation and Disclosure

Stakeholder consultation is a pivotal aspect of the project's implementing phase, ensuring that the perspectives and concerns of all relevant parties are considered in the project's execution. The implementing agency actively engages with a diverse range of stakeholders, including local communities, government authorities, environmental organizations, and other interested groups, throughout the project's lifecycle.

The consultation process is structured and inclusive, employing various methods such as public meetings, focus group discussions, surveys, and workshops to gather input and feedback. These interactions provide valuable insights into the social, environmental, and economic implications of the project, enabling the implementing agency to address any concerns and incorporate stakeholder recommendations into project planning and decision-making.

The stakeholder consultation was conducted in accordance with the principles of transparency, inclusivity, and responsiveness. **Table 14** details the public consultations conducted to discuss and disclose the project objectives to the fishing communities. The implementing agency ensured that stakeholders were informed about the project's objectives, activities, and potential impacts and that their input was given due consideration. Regular updates will be provided to stakeholders to keep them informed of the project's progress and any changes to its implementing.

Overall, stakeholder consultation plays a crucial role in enhancing the project's social acceptability, environmental sustainability, and overall success. The implementing agency is committed to promoting meaningful engagement with all stakeholders to achieve the best outcomes for the project and the communities it impacts.

Table 14: Details on Stakeholder Consultation

Sl.no	Consultation	Date/Place	Participation	Objective
1.	Tuticorin District Administration & NABARD	24.09.2022	● Member of Parliament, Tuticorin ● Researchers from research organizations ● Officials from Forest and Fisheries Department, Govt. of Tamil Nadu ● Fishermen ● Panchayat President, Vellapatti ● NABARD officials ● Officials from district administration	Implementation and success of NAFCC project in Vaan Island and assessment of status of coastal ecosystem and islands Protection and restoration of highly eroded Koswari and Kariyachalli Islands by following the successful Vaan Island model
2.	Tamil Nadu Forest Department	11.06.2024	Women (10) and men(13) from the fishing community belonging to the villages of Thirespuram, Mottaigopuram, Siluvaipatti, Vellapatti,	To discuss about the proposed project in deploying the artificial reef units surrounding the Karyachali Island and to get their feedback on Vaan island where the similar

Sl.no	Consultation	Date/Place	Participation	Objective
			Tharuvaikulam, Pattinamaruthoor, Sippikulam, Vaipar, Periyasamipuram and Vembar	activity has already been done.

6.1. Public Consultation outcomes

The outcome of the public consultation conducted on 11th June 2024 has been discussed in the following paragraphs. A public consultation meeting has been organised by the Tamil Nadu Forest Department to discuss the proposed project components (i) Multipurpose Artificial Reef (AR) Modules (ii) Coral rehabilitation, (iii) Seagrass rehabilitation and (iv) Eco development activities. The meeting was attended by women and men from the fishing community belonging to the villages of Mottaikopuram, Siluvaipatti, Thaurvaikkulam, Pattinamaruthur, Sippukkulam, Keezha Vaipar and Vembar.

During the consultation it was observed that the villagers were aware of the deployment of Artificial reef (AR) modules around Vaan Island a few years ago. Regarding the current project, the villagers expressed no difficulties caused to them due to the deployment of the AR modules. They believe that deployment of AR modules not only protects the Island but also would lead to form breeding and nursery grounds for inshore fish. They feel that the young ones will migrate to inshore waters and contribute to fisheries. The villagers fish beyond 1 km around the Islands and catch fish worth Rs.1000 to 2000 per day. They also hope that the coral rehabilitation activity will increase the coral cover, enhance the stability of the Island and increase reef fishery which would benefit them. The Islanders recall the role played by the coral reefs of the islands in protecting the mainland during the 2004 Sumatra Tsunami.

The women representatives (almost 10 in numbers belonging to Self Help Group) expressed that the micro-credit scheme which is benefitting them to earn their livelihoods needs to be augmented with an increased credit amount*[2]. They requested for construction of a community hall at Keezha Vaipar and other villages to facilitate conducting meetings among the group members.

The participants requested training on tailoring for women youngsters to earn their livelihoods. The fishermen requested training on crane operation, Outboard motor repairing, etc., for the youngsters as many diploma engineering graduates are without employment. These would help them to build a career for themselves.

*2 Each member of SHG gets from Rs.50000 to Rs.1 lakh @interest rate of 5.5% for a period of 10 months. They engage in textile, fish products, grocery selling etc., They requested more credit amounts like Rs.2 lakh per head, as it would help them to earn more income which can be used to educate their children at professional and post-graduate levels

Few Snap Shots from the meeting

Focus group discussions were conducted on 12th June 2024 in Tharuvaikulam, Vellapatti, Keezha Vaipar and Sippukulam coastal villages. Spot opinion was also gathered during the visit to the shore. The villagers of Tharuvaikulam feel that the erosion control measures using AR modules cause no problems for their fishing activity and suggested to ensure that the deployment arrangements do not obstruct the passage for movement of the boats between the Islands.

The Women belonging to Eco-Development Committees from Keezha Vaipar, Sippikulam, Tharuvaikulam, and Vellapatti stressed the need to provide training on tailoring to women which would help them to get jobs in the ready textile industry and also earn their income. Further, they expressed that the loan given by the GOMBRT is very useful to meet family expenses especially to educate their children up to the post-graduate levels and in professional courses.

Overall, the project activity on the restoration of Kariyachalli Island from erosion using AR modules received a positive response from the villages near the Island. Minutes of the public consultation are enclosed in **Annexure 7**.

Few Snap Shots from the FGD's

A summary of Focus Group discussions held with women is provided in the Table 15.

Table 15. Outcome of Focus Group Discussions during a field visit in June 2024

Date and Location	Information Disseminated	Response/opinion
12/6/2024 Sippikulam and Vaipar	Deployment of Artificial Reef (AR) modules to control erosion in Kariachalli Island, coral reef and seagrass restoration. Transport of fabricated structures of about 8000 numbers of AR modules and concrete frames and slabs for coral reef restoration and plastic quadrats for seagrass restoration. They will be transported from Tuticorin through crane barges. The benefits of the project include the stability of the island leading to protection of adjoining mainland during storms, AR modules providing shelter for fish and forming spawning and nursery grounds for a variety of animals. Coral reef restoration will do almost the same function.	The women folk are also aware of the existence of the Islands and coral reefs, and they expressed that the proposed activities will benefit the fishing communities to obtain better catch. They also believe that the islands protect them from natural disasters like cyclones. They were in support of the project activities. The livelihood support activities like providing micro-credit are useful to meet their expenses. They are engaged in textile, grocery business, etc and wish to continue in the future also. They requested training on tailoring for the younger women generation besides Palmyra craft making. The young men can be trained in crane operations and repair of Outboard Motor Engines used in

Date and Location	Information Disseminated	Response/opinion
	The project activities will lead to an increase in fish production for inshore areas and will help the artisanal fishing community to meet their livelihood needs. Adequate care will be taken while carrying structures in barges to avoid accidents with fishing vessels. The villagers will be informed of the schedule of movement of vessels from Tuticorin to Kariyachalli Island	Fiberglass boats.
12/6/2024 Tharuvaikulam village		The women also expressed the usefulness of the proposed activities. They requested training for women on embroidery and typing. The fishermen at the coast expressed that while transporting the materials through barges, their nets should not be damaged.
12/6/2024 Vellapatti		The women's group is well aware of the advantages of coral reefs and the presence of the Island. They felt these islands needed to be protected for sustained fishery production and supported the proposed activities. They are engaged in a variety of small businesses including fish and prawn pickle making which are in good demand. They felt an increase in credit amount from the present Rs.70000/1 lakh to Rs 1.5 to 2.0 lakhs would greatly benefit them to earn better income and the amount can be used to educate their children to post-graduate/engineering levels. The credit scheme, which is providing a supplementary income to the family, needs to be continued.

7. Environmental and Social Management Plan (ESMP)

The Environmental and Social Management Plan (ESMP) has been developed, based on the impact assessment (refer Chapter 5) to provide mitigation measures to reduce the negative impacts to acceptable levels. Unlike other projects, three ESMPs have been prepared for various subproject activities viz (i) Deployment of multipurpose artificial reef (AR) modules, (ii) Coral Rehabilitation, and (iii) Seagrass Rehabilitation. The ESMP includes a monitoring program to measure the environmental condition and effectiveness of implementation of the mitigation measures. It will include observations on- and off-site, document checks, and interviews with workers and beneficiaries. The ESMPs will be included in the bid and contract documents to ensure compliance with the conditions set out in this document. The following tables 16-18 show the potential environmental impacts, proposed mitigation measures and responsible agencies for implementation and monitoring.

The AR modules have been designed based on modelling techniques to ensure flawlessness in design, fabrication, movement and seating on the seafloor. Once they are placed, they will be monitored for alignment. If any of the modules found to be misaligned they will be corrected during the monitoring period.

Table 16: Environment and Social Management Plan (ESMP) for Deployment of Multipurpose Artificial Reef

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
Stage of Action – Project Design Stage							
Fabrication of concrete based AR Modules and their deployment	Weathering/ leaching of concrete materials may be a source of contaminant in the sea and may affect water quality ESS 1 and ESS 3	Use of stable/non-corrosive cement for fabrication of AR modules or appropriate eco-friendly additive for concrete stability in the sea	**XX**		**XX**	Wildlif Warden, Gulf of Mannar (WLW-GoM)	Forest Dept, GoTN
Site arrangements for deployment of AR modules on the seabed	● Reduction of benthic organisms due to partial masking of seabed ● Likely increase in predation of small fish/some species ESS 1 and ESS 6	● Adequate spacing of AR modules for the development new colonies of benthic organisms ● Natural phenomena and lost fish will be replaced over time	- **XX**		**XX**	WLW, GoM	Forest Dept, GoTN
Stage of Action – Preconstruction							
Fabrication of AR modules	Impacts on labour and community health due to poor Labor camps & facilities ESS 2 and ESS 4	● Comply with IFC EHS Guidelines on Occupational Health and Safety ● Develop a comprehensive site-specific health and safety (H&S) plan. ● The location, layout and basic facility provision of each labour camp will be submitted to the Site / Project Engineer prior to their construction. ● Accommodation of workers will follow the standards as per Workers' accommodation: processes and standards - a guidance note by IFC and the EBRD	**XX**		**XX**	Contractor	PMC/ Forest Dept, GoTN

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		(English). IFC E&S Washington, D.C.: World Bank Group. ● GRM will be established by the contractor to record and sort out the issues among the labourers ● The construction will commence only upon the written approval of the PMC ● The Contractor shall construct and maintain all labour accommodations in such a fashion that uncontaminated water is available for drinking, cooking and washing. ● The contractor shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of in a hygienic manner as approved by the PMC. ○ Corresponding personal protective equipment for concrete and cement mixing and also while loading the structures					
	Sources of construction materials - Impact on natural land contours, vegetation, disturbance to natural drainage patterns, water logging, and water pollution	● Obtain construction materials only from government-approved quarries with prior approval of PMC/ Forest Dept, GoTN ● PMC/ Forest Dept, GoTN to review, and ensure that proposed quarry sources have all necessary clearances/	--		**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		permissions in place prior to approval					
Stage of Action – Construction							
Impact on the Terrestrial environment							
Fabrication of AR modules	Removal of vegetation due to land clearing of site for Artificial Reef construction and temporary work areas for material storage and loss of biodiversity ESS 1, ESS 2, ESS 3, ESS 4 and ESS 6	● Land clearing only to be undertaken in approved areas approved by PMC/ Forest Dept, GoTN ● Any areas temporarily cleared are to be rehabilitated using native seed	**XX**	Weekly	**XX**	Contractor	WLW, GoM
	Contaminants released to the soil during Artificial Reef construction activities -Adverse impact on soil quality	Contractor to develop a construction Material Management Procedure including but not limited to the following ● Ensure stockpiles of bulk materials are well contained and separated from exposed soils ● Training for personnel in the implementation of safe work practices to minimise risks and impacts of spillage of fuels, chemicals and other contaminants ● Record and report chemical and hazardous substance spills; and ● Ensure personnel have access to spill kits that contain an absorbent material and contaminated disposal sites	**XX**	Weekly	**XX**	Contractor	WLW, GoM
	Noise generated and received through the	Contractor to develop a Noise Management Plan. EPA Standards	**XX**	Weekly	**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	movement of heavy vehicles delivering construction materials.	in dB(A) are: Gross vehicle weight upto 4 tonne -80 Gross vehicle weight more than 4 tonne but upto 12 tonne = 83 Gross vehicle weight more than 12 tonne =85					
	Dust generation due to construction activities Adverse health impacts on local communities and flora (if the dust settles on foliage)	Contractor to develop a Dust Management Plan ● Watering of temporary roads and stockpile areas; ● Watering while unloading blue metal ● Watering down affected vegetation; ● Use of dust suppression equipment; ● The dust generated should not exceed PM_{10} – 100 µg/m^3 and $PM_{2.5}$ - 60 µg/m^3	**XX**	Daily	**XX**	Contractor	WLW, GoM
	Air pollution due to Emission from Construction Vehicles, Equipment and Machinery	● The discharge standards promulgated under the Environmental Protection Act (https://cpcb.nic.in/displaypdf.php?id=aG9tZS9haXItcG9sbHV0aW9uL1JlY3ZlZC1OYXRpb25hbC5wZGY=) will be strictly adhered to. ○ SO_2 - 80 µg/m^3 ○ NOx - 80 µg/m^3 ○ PM_{10} – 100 µg/m^3 ○ $PM_{2.5}$ - 60 µg/m^3 ● All vehicles, equipment and machinery used for		Daily		Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		construction will conform to the relevant Standard. ● All vehicles, equipment and machinery used for construction will be regularly maintained to ensure that pollution emission levels comply with the relevant requirements. ● All the construction vehicles shall have Pollution Under Control (PUC) certificates to check air pollution.					
	Storage of construction materials Visual impact, air pollution and health hazardous	● The contractor shall identify the site for temporary use of land for construction sites /storage of construction materials, etc. ● No construction materials should be stored on the road, on top of or beside drains and footpaths, or on any other public area as this may restrict public access to these utilities, or in such a way that such storage would not be dangerous for moving people or traffic. ● Site for storage of construction materials to be identified without affecting the traffic and other common utilities, and the quality of the construction materials ● Construction materials should only	**XX**	Weekly	**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		be stored and prepared on the site if they do not obstruct the road or any surrounding public utility. ● Construction materials should only be transported to the worksite as and when required for construction ● Storage space shall be well defined and marked / with signboards					
	Storage of construction wastes - Soil and water pollution	● Fuel and lubricant storage areas shall be designed in such a way that oil may not contaminate soil or water. ● The floor of storage area shall be protected by an impermeable membrane and covered by a roof so that it is not affected by rain. ● Dispose waste oil and lubricants that have been generated as per provisions of Hazardous Waste (Management and Handling) Rules, 1989, at designated disposal sites ● Inspect all vehicles daily for fluid leaks before leaving the vehicle staging area, and repair any leaks before the vehicle resumes operation ● Strictly prohibit open defecation by workers in nearby areas	**XX**	weekly	**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	Health impacts while handling fabrication materials	All workers employed in mixing asphaltic material, cement, concrete etc., will be provided with protective footwear and protective goggles. Workers, who are engaged in welding works, will be provided with welder's protective eye-shields. Workers engaged in stone breaking activities will be provided with protective goggles and clothing and will be seated at sufficiently safe intervals. Personal Protective Equipment (PPE) will be provided for workers and will ensure adequate safety measures for workers during the handling of materials . Gloves, masks, face shield, coveralls and respirators will be provided as required Avoiding night-time working due to safety reasons	XX	Weekly	XX	Contractor	WLW, GoM
	Pollution issues while Clearing of Construction Camps & Restoration	Contractor to prepare site restoration plans for approval by the PMC ● On completion of the works, all temporary structures will be cleared away, all rubbish should be removed, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the Contractor's expense, to the entire satisfaction of the PMC. Disposal should	xx	Daily	**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		be at the sites designated by the local body					
Action Stage: Transport and deployment of AR modules							
Transport of AR modules	Vessel strike of marine fauna ● Injury to marine fauna (dugongs, turtles, dolphin) ● Possible oil leak while navigating ● Possible injuries to human while loading and unloading AR modules ● ESS 1, ESS 3 and ESS 6	● Vessel movement controls, speed limits, no-go zones ● Marine fauna observation and avoidance ● Constant check on oil levels while on cruise ● Adopting safety norms ● Before loading, the contractor shall be required to dispose of all items, materials and substances he has removed from the barge, in an environmentally friendly manner and in line with the rules and regulations stipulated by the TNPCB.	**XX**	Daily	**XX**	Contractor	WLW, GoM
	Pollution (air, noise, water etc.) and solid waste while loading and unloading of AR units	● The contractor shall take all necessary measures to ensure that: ● Any land-based residue left shall be removed by the contractor within a week whilst any sea borne refuse caused by the works will be immediately collected; ● All waste materials, goods and substances resulting from the work undertaken by the contractor are disposed of in an environmentally friendly manner and in line with the rules		Daily		PMC	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		and regulations stipulated by the TNPCB; ● No pollution is caused by the contractor for the purposes of carrying out the contract, either to the land or waters; ● No visible foam, oil, grease, scum, litter or other objectionable matter shall be present on the waters within the AR units deployment sites; and ● Due care should be taken during work to avoid unnecessary disturbance of the seabed or the creation of plumes of muddy water					
	Impact on biodiversity by the barge	● Barge loaded with artificial reef modules has to be properly anchored so that it does not damage the existing benthic coral and seagrass habitats ● Any waste or spills present in the barge or barge towing vessel should not be disposed of inside the sea but be taken to the shore for proper disposal ● Transporting of artificial reef modules to the proposed deployment site should be halted whenever the sea condition is rough. ● Transporting of artificial reef modules through regular fishermen track and	XX		XX		

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		fishing grounds should be avoided					
Deployment of AR units	Impact on the natural reef ESS 1, ESS 2, ESS 3 and ESS 6	● Choosing deployment site away from coral reefs and seagrass beds If any isolated coral patches are seen on the alignment, diversion can be taken or if it is not possible, placing of artificial reef modules has to be avoided in such locations, so that they can act like artificial reef structure ● Scientific professional divers with expertise in coastal habitats have to be involved in assisting during deployment ● Contractor shall be required to carry out and complete deployment of the artificial reef units in the shortest possible span of time so as to minimize any adverse impacts caused during deployment	**XX**	Daily	**XX**	Contractor	WLW, GoM
	Poor visibility due to turbidity	● In case of poor visibility due to turbidity Deployment of artificial reef modules has to be halted temporarily ● Regular monitoring will be helpful to avoid any impact to the surrounding habitats ● The effects of deployment of artificial reef modules in the marine environment should be evaluated by	**XX**	As and when required	**XX**	Contractor	WLW, GoM

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		analyzing the suspended solid loads in the water column					
	Accidental risk during ARs deployment	Safety protocols and risk management measures as per DAN World (https://world.dan.org/safety-prevention/diver-safety/safe-diving-practices/) have to be prioritized to ensure the well-being of scientific professional divers with expertise in coastal habitats (Coral and Seagrass beds) and other personnel involved in the artificial reef deployment operation.	**XX**	Daily	**XX**	Contractor	WLW, GoM
	Noise Pollution	As the reef and seagrass areas act as nurseries, breeding spots for green turtles and Dugongs, whenever the deployment work is not in process, the cranes and machine of vessels have to be stopped to avoid noise pollution	-	Daily	-	Contractor	WLW, GoM
	Potential hazards and address unforeseen challenges	Comprehensive safety briefings, equipment checks, and emergency response drills have to be conducted for divers and other labourers involved in the AR deployment activities	**XX**	Dail	**XX**	Contractor	WLW, GoM
	Loss of benthic organisms due to partial masking of seabed occupation by 8500 AR modules	Adequate spacing of modules to minimise loss and also monitoring the formation of new colonies of benthos on AR modules as a compensation to the loss.	-	Daily	**XX**	Consultant	WLW, GoM
Post Deployment							
Monitorin	Minor turbidity	Taking adequate care	-	Weekly	**XX**	Consult	WLW/For

Activity	Potential Environmental and Social impacts (and relevant ESS)	Mitigation Measures	Cost Rs. In lakhs	Monitoring requirements and Frequency	Cost Rs. In Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
g of water quality, biological organisms and fish population	during underwater observations by divers	to minimise water column turbidity		to quarterly for 24 months		ant	est Department

Table 17: Environment and Social Management Plan (ESMP) for Seagrass Restoration

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost in Rs lakhs	Monitoring requirements and Frequency	Cost in Rs. Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
Stage of Action - Pre-Transplantation							
Planning of Seagrass Restoration and Target Site Selection	● Impacts on seawater, existing seagrass habitats and other marine flora and fauna within the Island ● ESS 1 and ESS 6	● Assessment of Impacts for minimizing through precautionary measures ● The selected restoration sites shall be free from sources of physical stress such as erosion, deposition, etc.	**XX**	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN
Permits/ Clearances/ Approvals	Postponement in obtaining the permits/ clearances/	All the necessary approvals/ permissions/	-		-	WLW, GoM	Forest Dept, GoTN

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost in Rs lakhs	Monitoring requirements and Frequency	Cost in Rs. Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	approvals will delay the work and thereby lead to an increase in the project cost	clearances/ approvals should be obtained prior to the start of the construction					
Construction of PVC Quadrats	● Temporary solid waste Pollution impacts on the surrounding area ● ESS 3	● Use of eco-friendly materials instead of PVC ● Disposal of solid waste at designated sites	**XX**	Daily	**XX**	WLW, GoM	Forest Dept, GoTN
Action Stage: Transportation and restoration							
Transport of PVC frames using barges	● Possibility of accidents at sea and likely disturbance to artisanal fishermen and damage to their nets ● ESS 2 and ESS 4	● Transportation needs to be planned during calm sea conditions to ensure the safety of personnel ● Avoiding the routes where fishermen do fishing	**XX**	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN
Collection of Seagrass Shoots from Donor Sites	● May create stress if not collected from appropriate donor sites and	● Donor sites to be selected very close to the restoration sites so	**XX**	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost in Rs lakhs	Monitoring requirements and Frequency	Cost in Rs. Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	in a careful manner ● ESS 6	that the sprigs can have similar environmental conditions. ● Collection of seagrass shoots from healthy and abundant donor sites in such a way that it will minimize the stress on existing healthy habitats. ● To reduce the stress on the donor sites and to allow their recovery, collection of sprigs will be restricted to less than 5% of the donor site. Collectors need to be trained					

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost in Rs lakhs	Monitoring requirements and Frequency	Cost in Rs. Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
		properly to take care of existing donor sites					
Manual Transplantation of sprigs/ Deployment of PVC frames tied with Seagrass shoots and Transplantation of Seagrass at target sites	● Limited and localized Impact on existing marine habitat ● PVC pollution ● Impact on the marine process due to the deployment of foreign materials (PVC frames) ● Limited impacts on protected marine habitats en route if any during transportation of PVC frames to the site ● ESS 6	● Suggested Actions based on impact assessment studies and similar experiences of activities prior. Use of eco-friendly materials like bamboo instead of PVC	**XX**	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN
Stage of Action – Post-Transplantation							
Restoration Process (Monitoring and Maintenance)	● Solid wastes and disturbed PVC frames within seawater due to	● Removing solid wastes, torn pieces of nets and seaweed Replacing	**XX**	Quarterly	**XX**	WLW, GoM	Forest Dept, GoTN

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost in Rs lakhs	Monitoring requirements and Frequency	Cost in Rs. Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	marine processes and fishing activities ● ESS 3 and ESS 4	disturbed PVC frames					

Table 18: Environment and Social Management Plan (ESMP) for Coral Reef Restoration

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost Rs. In Lakhs	Monitoring Requirements and Frequency	Cost Rs.in Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
Stage of Action - Pre-Transplantation							
Selection of rehabilitation site/s by underwater survey and identification of donor sites	● Impacts on seawater, especially the creation of turbidity by divers ● ESS 3	● Divers be trained to avoid the creation of turbidity while inspecting the sites.	**XX**	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN
Construction of concrete frames and small cement slab substrates for coral settlement	● Pollution at the construction site due to spillage of materials ● ESS 3	● Disposal of wastes at designated sites	**XX**	Daily	**XX**	WLW, GoM	Forest Dept, GoTN
Transport of concrete frames and cement slabs using barges for a distance of 20 km	● Possibility of accidents at sea and likely disturbance to artisanal fishermen and	● Transportation needs to be planned during calm sea conditions to	**XX**	NA	**XX**	WLW, GoM	Forest Dept, GoTN

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost Rs. In Lakhs	Monitoring Requirements and Frequency	Cost Rs.in Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
	damage to their nets ● ESS 2 and ESS 4	ensure the safety of personnel ● Avoiding the routes where fishermen do fishing					
Stage of Action: Deployment of frames and transplantation							
Deployment of concrete frames on seabed by divers	● Likely creation of turbidity in the water column ● ESS 3	Divers be trained for placement of frames on the seabed in a manner to avoid the creation of turbidity	**XX**	NA	**XX**	WLW, GoM	Forest Dept, GoTN
Cutting coral fragments (8-11 cm size) of identified native coral at the nearby identified donor reefs with a maximum of 3-5% of the colony size and tied firmly with cement slabs (20 cm x 5 cm x1.5 cm) using nylon rope and then tied onto the frames already deployed.	● Likely damage at donor reef sites while cutting and plastic pollution due to detachment of nylon ropes ● ESS 6	● Utmost care should be taken while cutting donor corals and periodic checking for detachment of nylon ropes	-	Weekly	**XX**	WLW, GoM	Forest Dept, GoTN
Placing of cement slabs	● Possibility	● Divers to	-	Weekly	**XX**	WLW, GoM	Forest Dept,

Activity and Environmental aspects	Potential Environmental and Social impacts	Mitigation Measures	Cost Rs. In Lakhs	Monitoring Requirements and Frequency	Cost Rs.in Lakhs	Responsibilities	
						Planning and Execution	Supervision/ Monitoring
on the concrete frames and coral transplantation on cement slabs	of creation of low-level water column turbidity and coral slabs to mask benthic fauna on the seabed ● ESS 3 and ESS 6	be trained to place the slabs avoiding the creation of turbidity. Checking of formation of new colonies of benthic fauna around the slabs					GoTN
Stage of Action: Post-deployment							
Monitoring and maintenance of rehabilitated sites	● Avoiding the creation of water column turbidity while observing the slabs while replacing damaged slabs or slabs with no coral growth ● ESS 3	Divers to be trained to avoid turbidity around the cement slabs	-	Weekly for the initial 3 months and monthly afterwards	**XX**	WLW, GoM	Forest Dept, GoTN

7.1 Construction and Post-Construction Monitoring Plan

Comprehensive and regular monitoring during the deployment of artificial reef modules phase is crucial to manage the environmental impacts and to protect the environmental health and biodiversity. Systematic monitoring would help to ensure the success of the project, understand the status of environmental health during the deployment period and accordingly the management and remedial action could be taken up. Constant monitoring of island morphology, bathymetry, environmental parameters, benthic habitats, fish assemblage and fishery resources should be in place to take effective management and remedial actions in the face of any adverse impacts. Table 19 details the parameters to be monitored, locations and monitoring frequency during the AR modules construction phase before starting the deployment. It will provide the baseline data. Table 21 details the parameters to be monitored, locations and monitoring frequency during the AR modules deployment/ phase, coral reef restoration and seagrass restoration

Table 19: Details of monitoring Components, Parameters, Locations and Monitoring Frequency during the Construction Phase (Baseline)

Sl.no	Components	Parameters to be Monitored	Locations		Monitoring frequency
I – Sedimentation					
1	Sedimentation	Rate of sedimentation & sediment textures	6 locations covering Kariyachalli and Vilanguchalli islands		**Once(One time)**
II – Environmental Parameters					
2.	Marine Water Quality	<u>Physical properties:</u> Temperature, Salinity, pH, Electrical Conductivity (EC), Turbidity, Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Visibility <u>Chemical Properties</u> Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD)	20 (Surface and bottom) stations covering island reef areas, patch reef areas and seagrass habitat		**Once(One time)**
		<u>Chemical properties</u> Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) <u>Heavy metals:</u> Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt <u>Bacteriological parameters:</u> Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus*	20 (Surface and bottom) stations covering island reef areas, patch reef areas and seagrass habitat		**Once(One time)**

Sl.no	Components	Parameters to be Monitored	Locations		Monitoring frequency
		faecalis, Shigella count, *Salmonella* count Marine Biology **Pigment Parameters:** Chlorophyll–a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices			
3.	Marine Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC), oil and grease	20 locations covering island reef areas, patch reef areas and seagrass habitat		**Once(One time)**
		Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	20 locations covering island reef areas, patch reef areas and seagrass habitat		**Once(One time)**
III – Underwater assessment					
4.	Coral reef habitat	Coral reef benthic community structure, density & diversity, coral health issues, coral growth on restoration slabs, reef fish community & macrofauna	12 locations covering island reef areas and patch reef areas		**Once(One time)**
5.	Seagrass habitat	Seagrass community structure, shoot density, seagrass associated fish community & macrofauna both at restored place and other locations	8 covering seagrass habitat		**Once(One time)**
IV – Other studies					
6.	Island Morphology	Kariyachalli Island morphology (Shoreline changes and elevation)	Entire island		**Once(One time)**

Sl.no	Components	Parameters to be Monitored	Locations		Monitoring frequency
7.	Bathymetry	Kariyachalli and Vilanguchalli Islands	Up to 2 km around the island		**Once(One time)**
8	Fish resource survey	Kariyachalli island	Around the proposed artificial reefs areas		**Seasonal**

Table 20: Details of monitoring Components, Parameters, Locations and Monitoring Frequency during the Deployment Phase of AR modules, coral restoration and seagrass restoration activities

Sl.no	Components	Parameters to be Monitored	Locations		Monitoring frequency
I – Sedimentation					
1	Sedimentation	Rate of sedimentation & sediment textures	6 locations covering Kariyachalli and Vilanguchalli islands		**Monthly**
II – Environmental Parameters					
2.	Marine Water Quality	Chemical properties Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Pigment Parameters:** Chlorophyll–a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices	20 (Surface and bottom) stations covering island reef areas, patch reef areas and seagrass habitat		**Seasonal –** Summer, Pre-monsoon, monsoon, post-monsoon,
3.	Marine Sediment Quality	Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli,*	20 stations covering island reef areas, patch reef areas and seagrass habitat		**Monthly**

Sl.no	Components	Parameters to be Monitored	Locations		Monitoring frequency
		Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella count, *Salmonella* count Marine Biology **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices			
	Noise and dust levels at AR modules construction site	Noise and dust levels at and ambient noise and dust levels	Construction site and 500m around the site		**Daily till modules are transported and reach the harbour**
III – Underwater assessment					
4.	Coral reef habitat	Coral reef benthic community structure, density & diversity, coral health issues, coral growth on restoration slabs, reef fish community & macrofauna	12 locations covering island reef areas and patch reef areas		**Seasonal –** Summer, Premonsoon, monsoon, post-monsoon,
5.	Seagrass habitat	Seagrass community structure, shoot density, seagrass associated fish community & macrofauna both at restored place and other locations	8 locations covering seagrass habitat		**Seasonal –** Summer, Premonsoon, monsoon, post-monsoon,
IV – Other studies					
6.	Island Morphology	Kariyachalli Island morphology (Shoreline changes and Elevation)	Entire island		**Monthly except monsoon**
7.	Bathymetry	Kariyachalli and Vilanguchalli Islands	Up to 2 km around the island		**Once in 6 months**
8	Fish resource survey	Kariyachalli island	Around the proposed artificial reefs areas		**Seasonal**

Following **Table 21** details the parameters to be monitored, locations and monitoring frequency during the post deployment phase of AR modules, coral restoration and seagrass restoration activities.

Table 21: Details of monitoring Components, Parameters, Locations and Monitoring Frequency during the Post Deployment Phase of AR modules, coral and seagrass restoration activities

Sl.no	Components	Parameters to be Monitored	Locations	Monitoring frequency
I	**Artificial reefs**	**Alignment, stability and degradation**	**Entire modules**	**Quarterly**
II – Sedimentation				
1	Sedimentation	Rate of sediments & sediment textures	6 locations covering Kariyachalli and Vilanguchalli Islands	**Monthly**
III– Environmental Parameters				
2.	Marine Water Quality	Chemical properties Ammonia, Nitrite, Nitrate, Total Nitrogen, Inorganic Phosphate, Total Phosphate, Silicate, Petroleum Hydrocarbon (PHC) Heavy metals: Copper, Ferrous, Nickel, Mercury, Magnesium, Chromium, Arsenic, Lead, Zinc, Cobalt Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Pigment Parameters:** Chlorophyll–a, Phaeo-pigments, Total biomass **Phytoplankton:** Primary Productivity, Population Density, Percentage Composition, Diversity Indices **Zooplankton:** Population Density, Percentage Composition, Diversity Indices	20 (Surface and bottom) stations covering island reef areas, patch reef areas and seagrass habitat	**Seasonal –** Summer, Premonsoon, monsoon, post-monsoon,
3.	Marine Sediment Quality	Physical & Chemical properties: Soil pH, Soil Texture (Sand, Silt, Clay), Organic Matter, Total Nitrogen, Total Phosphate, Petroleum Hydrocarbon (PHC), oil and grease Heavy metals: Copper, Ferrous, Nickel, Mercury, Manganese, Chromium, Arsenic, Lead, Zinc, Cobalt, Cadmium, Selenium Bacteriological parameters: Total Viable Count, Total Coliform, Faecal Coliform, *Escherichia coli, Vibrio cholera, Vibrio parahaemolyticus, Pseudomonas aeruginosa, Streptococcus faecalis, Shigella* count, *Salmonella* count Marine Biology **Macro-benthos:** Population Density, Percentage Composition, Diversity Indices **Meio-benthos:** Population Density, Percentage Composition, Diversity Indices	20 stations covering island reef areas, patch reef areas and seagrass habitat	**Monthly**

Sl.no	Components	Parameters to be Monitored	Locations	Monitoring frequency
I	**Artificial reefs**	**Alignment, stability and degradation**	**Entire modules**	**Quarterly**
IV – Underwater assessment				
4.	Coral reef habitat	Coral reef benthic community structure, density & diversity, coal health issues, reef fish community &macrofauna both at restoration places and reef locations	12 locations covering island reef areas, patch reef areas	**Seasonal –** Summer, Premonsoon, monsoon, post-monsoon,
5.	Seagrass habitat	Seagrass community structure, shoot density, seagrass associated fish community & macrofauna both at restoration locations and other areas	8 locations covering seagrass habitat	**Seasonal –** Summer, Premonsoon, monsoon, post-monsoon,
V – Others				
6.	Island Morphology	Kariyachalli Island morphology (Shoreline changes and Elevation)	Entire island	**Seasonally except monsoon**
7.	Bathymetry	Kariyachalli and Vilanguchalli Islands	Up to 2 km around the island	**Once in 6 months**
8	Fish resource survey	Kariyachalli island	Around the proposed artificial reefs areas	**Seasonal**

7.2 Monitoring and Reporting System and remedial measures

The environmental monitoring report for submission to the World Bank shall be on a quarterly basis during construction and on a semi-annual basis during operation. During the construction phase, the contractors will undertake the monitoring and reporting of the environmental and social parameters. In the case of coral and seagrass restoration activities, a quarterly progress report will be submitted by the Consultant to the Forest Department. In case of finding damaged or sunken AR modules in the site at sea, new module will have to be replaced by the contractor. Similarly for materials used for coral reef and seagrass restoration. If presence of invasive species of organisms is found, they will have to be removed and disposed as per hazardous materials management rules. The prepared quarterly monitoring reports shall be reviewed by the PMC/ Forest Department and TNGCC, Government of Tamil Nadu and then it will be shared with the World Bank. A third-party annual monitoring on performance of project activities will be carried out by the SPMU of TNGCC.

7.3 Cost Estimate for Environmental Monitoring Program

As per the DPR, the tentative cost for project monitoring (including Environmental parameters, as underwater surveys, Shoreline morphology, bathymetry and fishery as per EMP including boat, dive equipment's, manpower including profession researchers with dive capacity, travel, contingency etc)) is worked out to be Rs. XXX Lakhs (Table 22)

Table 22: Tentative cost for Project Monitoring

Sl.no	Sub-project Component	Implementation of ESMP and Project Monitoring	Total (in Lakhs)
1.	Multipurpose Artificial Reef (AR) Modules	Monthly and biannually Environmental parameters, as underwater surveys, Shoreline morphology, bathymetry and fishery as per EMP including boat, dive equipment, manpower including profession researchers with dive capacity, travel, contingency etc.	XXX
2.	Coral rehabilitation	Monitoring as per EMP requirement	XXX
3.	Seagrass rehabilitation	Monitoring as per EMP requirement	XXX
	Total		**XXX**

8. Grievance Redress Mechanism

The proposed Grievance Redress Mechanism allows not only grievances, but also queries, suggestions, positive feedback, and concerns of labours and project-affected parties related to the environmental and social performance of a project. Details are provided in Table 23.

8.1 Description of Grievance Mechanism (GM)

Table 23: Description of the process of GRM

Step	Description of process	Timeframe	Responsibility
GM implementation structure	SPMU headed by the Project Director, TN SHORE will be responsible for all sub projects related issues including grievance resolution. Each of the PEAs in 14 Districts will establish a Grievance Redressal Committee headed by the respective Head of District Offices viz. Wildlife Warden, District Forest Officers (DFOs), District Collectors, District Environment Engineers etc., The PEA's will keep records of grievances received, including contact details of the complainant, the date the complaint was received, the nature of the grievance, agreed corrective actions and the date these were affected and the final outcome. The project MIS will record and report on all complaints received from all the different mediums. The number of grievances recorded and resolved and the outcomes will be displayed/disclosed in the PIU's office, as well as reported in monitoring reports submitted to World Bank on quarterly or semi-annual basis. All resolutions shall be communicated to the aggrieved party / complainant(s)		SPMU at HQ PEAs (State and District Level)
Grievance uptake	Grievances will be submitted via the following channels • E-mail to SPMU, PEA, • Letter to SPMU, EIA, • In-person at a physical facility at the Office of the District Head offices • Grievance or suggestion boxes located at the Office of the District Head offices • Online form on the website		SPMU & PEAs (State and District Level)
Sorting, processing	Any complaint received is forwarded to respective Project Executing Agency such as the Department of Forest, Dept. of Environment & Climate Change and Tamil Nadu Pollution Control Board. Further, they shall be categorized according to the following complaint types:	Upon receipt of complaint	Local grievance focal points at the PEAs

Step	Description of process	Timeframe	Responsibility
	• Procurement and finance related • Land related (measurement, payment of compensation or other entitlements) • Construction stage issues (access, damages, non-payment of wages, etc.) • Others		
Acknowledgement and follow-up	Receipt of the grievance is acknowledged to the complainant by the Public Information Officer of each office nominated under the RTI, Act, 2005	Within 2 days of receipt	Public Information Officer
Verification, investigation, action	Investigation of the complaint is led by the head of the District Offices or his/her nominee A proposed resolution is formulated by the head of the District Offices and communicated to the complainant by the head of the District Offices	Within 14 working days	PEAs
Monitoring and evaluation	Data on complaints are collected and reported to SPMU on a monthly basis	Monthly	PEAs
Provision of feedback	Feedback from complainants regarding their satisfaction with complaint resolution is collected before the closure of the complaint in the system	Before closure of the complaint	PEAs
Training	Training needs for staff/PMC in the PEA, and Contractors are provided by the E&S experts at the PEA level	Every Six Months	PEAs
Appeals process	**Tier II**: All grievances that cannot be redressed within 14 days at the 1st tier (PEA District level) will be brought to the notice of the 2nd Tier i.e. PEA's (State Level) for resolution	within 14 days of receipt	PEA/SPMU
	Tier III If the grievance is not resolved at PEA's level, the grievance will be referred to SPMUS-Project Director TN-SHORE. The grievance at this level will be resolved	within 21 days of its receipt.	

The sub-project GRM notwithstanding, an aggrieved person shall have access to the country's legal system at any stage. This can run parallel to accessing the GRM and is not dependent on the negative outcome of the GRM.

In case of complaints relating to Sexual Exploitation and Abuse/Sexual Harassment (SEA/SH) complaints, these will be safely and ethically received and confidentially managed. Complaints in this regard will be forwarded directly by the PEA to the SPMU, for appropriate investigation and resolution therein ensuring that survivor/victim identity and case details are known only to key persons.

All costs involved in resolving the complaints (meetings, consultations, communication, and reporting/ information dissemination) will be borne by the PEA. PEAs will also ensure the setting up of labour GRMs by the various contractors and monitor their functioning. They will ensure that the contractors submit information on grievance management as part of the monthly progress reporting.

9. Institutional Mechanism

The project will be implemented as the '**Tamil Nadu Coastal Restoration Mission**' by the State Project Management Unit (SPMU) housed in the Tamil Nadu Green Climate Company (TNGCC) under the Department of Environment, Climate Change and Forests, Government of Tamil Nadu. The SPMU will be headed by a Project Director, comprising department officials and supported by PMC for implementation of technical, financial, procurement, environmental and social safeguards aspects. District Climate Change Missions (DCCMs) have been established in coastal districts with representatives from other departments for coordinating the project implementation in the field. (Fig 17)

A High Powered Steering Committee (HPSC) chaired by the Chief Secretary including all relevant senior officials has been established for oversight and guidance to steer convergence, regional integration, and coordinated actions. The HPSC will be chaired by the Chief Secretary and includes the Additional Chief Secretaries / Principal Secretaries of all participating line departments. Such vertical alignment and oversight and guidance from HPSC will ensure efficient and effective project delivery, facilitate interdepartmental coordination, and pave the way for convergence.

9.1 Project Management

The project will be implemented by the Department of Environment, Climate Change and Forests, Government of Tamil Nadu through a two-tier implementation structure: (i) State Project Management Unit housed in the Tamil Nadu Green Climate Company (TNGCC) under the Department of Environment, Climate Change and Forests, Government of Tamil Nadu; and; ii) Project Executing Agencies (PEAs) at the state level and through their field offices district level. In the present case, the PEA is the Forest Department through Wild Life Warden, Gulf of Mannar.

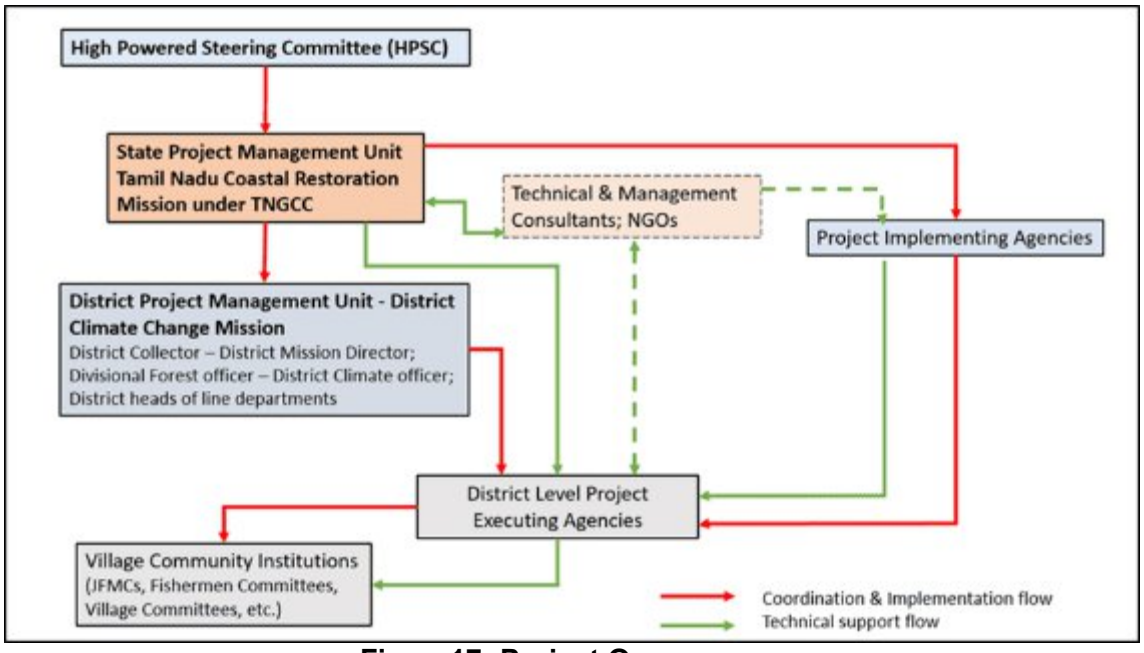


Figure17: Project Organogram

9.2 State Project Management Unit (SPMU)

Tamil Nadu Green Climate Company (TNGCC) is a registered Company under the Tamil Nadu under section 8 of the Companies Act 2013 and operates as a 'Not-for-Profit' Company created as a Special Purpose Vehicle (SPV) to implement the Tamil Nadu State Action Plan for Climate Change (TNSAPCC). The TNGCC is headed by the Additional Chief Secretary, Department of Environment, Climate Change and Forests, with a Board of Directors comprising Secretaries from key line departments. TNGCC is already implementing three pivotal government missions, viz.: i) Tamil Nadu Climate Change Mission; ii) Green Tamil Nadu Mission, and; iii) Tamil Nadu Wetland Mission. TNGCC will be implementing SHORE as a fourth mission called "Tamil Nadu Coastal Restoration Mission" and serve as the SPMU for SHORE (Figs 18 and 19). The SPMU in TNGCC shall bring increased synergy among different missions and ensure: i) greater convergence with other activities and schemes of the Government; ii) avoidance of duplication and double dipping; iii) strengthening the existing institutions, and; iv) improved coordination and adopting an integrated approach for coastal zone management. The SPMU will be headed by a Chief Mission Director/Mission Director who will be the project Director for TN-SHORE. The Board of Directors of TNGCC would support in interdepartmental coordination, approval of annual work plans and budget, and monitoring of the SHORE project. The SPMU will be staffed through internal staff from the Forest Department as well as supported by a team of technical (including environmental and social), finance, procurement and project administration specialists and PMC.

Figure 18: Structure of SPMU

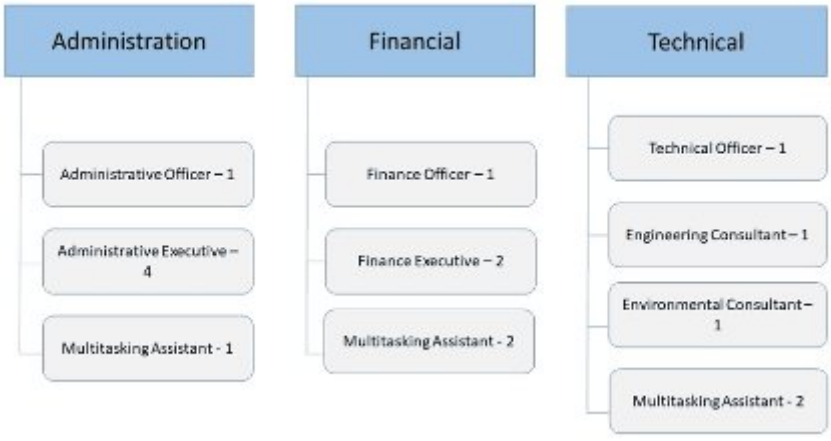


Figure 19: Supporting divisions of SPMU

9.3 Project Executing Agencies (PEAs)

The PEAs shall be responsible for the overall implementation of the activities pertaining to the respective coastal districts. The PEAs have head office at state level and the project on the ground will be implemented through the district Project Executing Agencies, which are at the

district level under the guidance of District Climate Change Mission. The PEAs will prepare the annual plans and budgets requirements, which will be approved by the SPMU. The PEAs will be responsible for management of contracts and implementation of community led activities with Village Committees/ JFMCs. The following implementing agencies have been identified: (a) SPMU in TNGCC at state level; (b) Tamil Nadu Pollution Control Board – PEA; (c) Green Tamil Nadu Mission – PEA implementation through District Forest Officers (DFO); (d) Tamil Nadu Forest Department – PEA implementation through DFOs (forests) / wild life wardens; (e) Conservation Authority of Pallikaranai Marsh Land – PEA; and (f) Department of Environment and Climate Change – PEA; (g) Tamil Nadu Wilderness Experiences Corporation - PEA and (h) District Rural Development Agency (DRDA) – PEA.

Table 24: Roles and Responsibilities

Agency/Individual	Roles and responsibilities
State Project Management Unit – PMU Including E&S specialists and communication expert)	● Review and approval of ESMF ● Coordinate among other implementation agencies/ ● Review and approve all sub-projects in respect of E&S aspects (screening, preparation of ESMP or inclusion of guidelines or inclusion of provisions within DPRs) ● Review reports submitted by PEAs and submit to WB for approval
District Project Executing Agencies	● Participate either themselves, or identify suitable representative, during all face-to face stakeholder meetings. ● Review and sign-off minutes of all engagement events; ● periodic reports to State level PEAs for review and onward sending to SPMU ● Assure participation/ inclusion of stakeholders from vulnerable groups. ● Management of contracts, implementation of community led activities with Eco development committees Village Committees/ Joint Forest Management Committees (JFMCs) etc.

- **Roles and Responsibilities of Environmental and Social Safeguard specialist at SPMU - TNGCC**
    - To verify periodically that all sub-projects are in line with the prevailing national, state and local legislation on the one hand, and the World Bank policies on the other.
    - To ensure that ESMF is being fully integrated with the SHORE sub-project appraisal cycle, by identifying the project category before issuing the Terms of Reference to the design consultants and evaluating the proposals with respect to their completeness and compliance.
    - To carry out Site Visits to sub-project implementation sites to monitor as well as provide onsite training as required. Prepare reports on visits / training to document the visit, observations for improvement required, need for follow-up etc.
    - To provide necessary documents to the external auditors for carrying out annual E&S audit.
    - To arrange to conduct analytical studies based on sub-project experience to influence policy changes that will lead to better management of environmental and social issues.
    - To retain documents, reports and other records pertaining to ESMF.
    - To prepare and submit quarterly progress reports to the GoTN, the World Bank and other agencies as required.
        - To report to Higher officials on all matters pertaining to ESMF

- **Roles and Responsibilities of Environmental and Social Safeguard specialist at PEAs**

  - Include design related measures of the ESMP in the project design and DPR;
  - Include ESMP in the bidding documents and civil works contracts, including requirement of staff (EHS supervisor) with contractor for ESMP implementation;
  - Provide necessary budget in the project for ESMP Implementation;
  - Ensure that the bid/contract documents include specific provisions requiring contractors to comply with all applicable labour laws and core labour standards including: (a) Labour welfare measures and provision of amenities; (b) Prohibition of child labour as defined in national legislation for construction and maintenance activities; (c) Equal pay for equal work of equal value regardless of gender, ethnicity, or caste; (d) Elimination of forced labour; (e) The requirement to disseminate information on sexually transmitted diseases, including HIV/AIDS/ COVID 19, to employees and local communities surrounding the project sites.
  - In the pre-bid meeting, provide insight into ESMP measures, and overall compliance requirements to the bidders; and
  - Obtain all clearance/permissions as required for implementation of subproject, prior to invitation of bids and/or prior to award of contract / prior to construction as appropriate.
  - Prior to start of construction organize an induction course for the training of contractors, preparing them on ESMP implementation, environmental monitoring, and on taking immediate action to remedy unexpected adverse impacts or ineffective mitigation measures found during the course of implementation.
  - Guide contractor on updating ESMP / preparing Construction - Environmental Management Plan (C-ESMP) at the start of the project.
  - Update ESIA and ESMP; ensure that ESIA reflects the final design being implemented by contractor.
  - Conduct public consultation and information disclosure as necessary;
  - Take corrective actions when necessary to ensure no environmental impacts;
  - Address any grievances brought about through the grievance redress mechanism in a timely manner as per the ESMP.
  - Implement corrective or preventative actions in case of non-compliance or new/unanticipated impacts.
  - Inform SPMU promptly in case if any significant impacts surfaces, which were not identified in the ESIA and develop necessary corrective actions as necessary and ensure implementation by the contractors; include all such impacts and suggested actions in the Quarterly Environmental Monitoring Reports;
  - Implementation grievance redress system, and undertake appropriate actions to redress the complaints; ensure that complaints/grievances are addressed in a timely manner and resolutions are properly documented;
  - Review and approve monthly progress reports submitted by Contractor on ESMP compliance;
  - Prepare quarterly environmental monitoring reports and submit to SPMU; and
  - Provide any assistance in environmental safeguard related tasks as required by SPMU to ensure compliance and reporting to World Bank.

- **Roles and Responsibilities of Environment, Health and Safety (EHS) supervisor at Contractor**

  - Understand the ESMP requirements and allocate necessary resources (budget, staff, etc.);

- Understand the regulatory compliance requirements related to labour welfare, safety, environment etc.
- Mobilize EHS Supervisor prior to start of construction work;
- Prepare C-ESMP and submit to PMC/ PEAs;
- Ensure that all regulatory clearances (both projects related and contractor related) are in place prior start of the construction work;
- Prepare and submit Construction waste management (CWM) plan and Traffic management plan;
- Implement the mitigation measures as per the ESMP including CWM and traffic management plans;
- Follow the ESMP measures/guidelines for establishment of temporary construction camps, construction waste disposal sites, and material borrow areas, etc.;
- Implement ESMP and ensure compliance with all the mitigation and enhancement measures;
- Conduct environmental monitoring (air, noise, water, etc.), as per the ESMP;
- Undertake immediate action as suggested by PMC/PEAs to remedy unexpected adverse impacts or ineffective mitigation measures found during the course of implementation;
- Submit monthly progress reports on ESMP implementation to PMC/PEAS;
- Act promptly on public complaints and grievances related to construction work and redress in a timely manner in coordination with PMC/PEAS; and
- Comply with applicable government rules and regulations.

- The Sub project will be implemented by following Institutional under supervision of SPMU (Administration Chart is attached in **Annexure 8**)

9.4. Post Project Recommendation

The baseline survey results should be documented and maintained as a database for future reference and analysis. The sub-project implementation details along with monitoring and verification data should also be documented in the form of status reports as well as sub-project report and submitted to the Principal Chief Conservator of Forests and Chief Wildlife Warden, Tamil Nadu Forest Department. This information should be made available for any future planned activities both in the region or elsewhere to be used as a case study.

During sub-project implementation, a detailed feedback should be collected from respective stakeholders including communities and SHGs to ensure meeting the ultimate objectives of the project. The data collected through the proposed sub-project activity will be the property of Govt. of Tamil Nadu that can be used for publication by implementing researchers with due acknowledgement to the Tamil Nadu Government and World Bank.

An**nexure 1**

Table: Timeline of project activities

	I year				II Year				III Year				IV Year			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Objective 1: *Deployment of multipurpose artificial reef (AR) modules* **-** To build climate change resilience to the fast-eroding Kariyachalli Island through deployment of multipurpose artificial reef modules and to restore ecological services.																
Preparation and procurement																
Underwater fixing of AR deployment location (southeast of the Kariyachalli Island) as per the lay out proposed by IIT Madras, avoiding coral area																
Construction and placing concrete of grade M40 for fabricating Artificial coral reef of size 2.5m x 1m x 2m(4250 Nos) and 4m x 1m x 3m(4250 Nos) including all labour, materials, tools, equipment, fuel, etc. Also, Supplying, fabricating, and placing of TMT, Fe500D grade steel for reinforcement welding, binding, with binding wire all as per drawing, technical specifications and including all labour, materials, tools transport, cage lowering, equipment, fuel etc (1% of concrete).																
Transportation and deployment of AR modules in the location as per the lay out proposed by IIT Madras.																
Monitoring various parameters during and post deployment of AR modules such as Marine water and																

sediment quality, Coral and seagrass habitats, Island Morphology, Bathymetry and fishery (including baseline)	
Objective 2: *Coral Rehabilitation* - To restore Habitats (Coral rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy.	
Selection of specific rehabilitation site within the identified degraded coral reef area by underwater survey	
Construction of substrates for fragment transplantation	
Deployment of substrates	
Coral transplantation	
Monitoring and maintenance of rehabilitated sites	
Objective 3:*Seagrass Rehabilitation* - To restore Habitats (seagrass rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy.	
Selection of specific rehabilitation site within the identified degraded seagrass area by underwater survey	
Development of transplantation substrate (PVC frame / Coir ropes)	
Seagrass shoots transplantation	
Monitoring and maintenance of rehabilitated sites	
Objective 4: *Eco development activities among coastal communities*- To enhance the coastal communities' adaptive capacity and to sustain livelihood and food security	
SHG related activities, which will include areas such as micro-credit provision, revolving funds, SHGs nurturing wherein alternate livelihood opportunities will be generated for the communities.	
Conservation of marine ecosystem through	

awareness creation for SHGs	
Reviving and nurturing SHGs	
Extending SHG loans to fishermen	
Construction of community hall, training facility and fish auction facility	
Imparting specific local skill upgradation training to fisherwomen SHG members (i.e. tailoring, embroidery, etc.)	
Imparting vocational training to fisher folk youth	
Biodiversity and SCUBA diving training	
Eco tourism and construction of interpretation-cum-training centre to carry out dissemination of information regarding GoM.	
Marine ornamental fish breeding with Clown Fish, Sea Bass, etc.	
Cage fish culture	

* construction, transport and deployment of AR modules will be completed within 18 month from start of project.

Annexure 2: List of references

i. https://onlinemaps.surveyofindia.gov.in/FreeMapSpecification.aspx. (The map presented in the diagram is drawn from the combination of different toposheets with serial numbers 58L/1, L/2, L/3, 58K/8, K/12, K/14, K/15, K/16, 58O/3, O/4, O/7, O/8)
ii. https://www.environment.tn.gov.in/environment/nafcc (Management and rehabilitation of coastal habitats and biodiversity for Climate Change Adaptation and Sustainable Livelihood in Gulf of Mannar)
iii. National Ambient Air Quality Standards, Central Pollution Control Board Notification in the Gazette of India, Extraordinary, New Delhi, 18th November, 2009
iv. https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health (Ambient (outdoor) air pollution)
v. Marine Fisheries Census 2016 - Tamil Nadu. (https://eprints.cmfri.org.in/17493/2/TAMIL%20NADU%20Marine%20Fisheries%20Census%20India%202016.pd) - Central Marine Fisheries Research Institute, Indian Council of Agricultural Research, Ministry of Agriculture and Farmers Welfare; Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India)
vi. Tutorin District profile - https://tnmines.tn.gov.in/pdf/dsr/8.pdf
vii. India Meteorological Department (IMD) - https://mausam.imd.gov.in/chennai/
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Annexure – 3: Wave dynamic study and design of artificial module for restoration of Kariyachalli Island, Gulf of Mannar

Wave dynamic study and design of artificial module for restoration of Kariyachalli Island, Gulf of Mannar

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FEBRUARY2024

Table of Content

List of figures

Introduction

Kariyachalli Island is located off Tuticorin coastline of Gulf of Mannar along the south east coast of India has been experiencing substantial erosion over the past several years, the rate of which being observed to be significant over the last couple of years. It is to be mentioned that the coral reefs has been serving as barriers to the onslaught of ocean waves or littoral barriers offering the very much needed protection of the sandy beaches of Kariyachalli island.

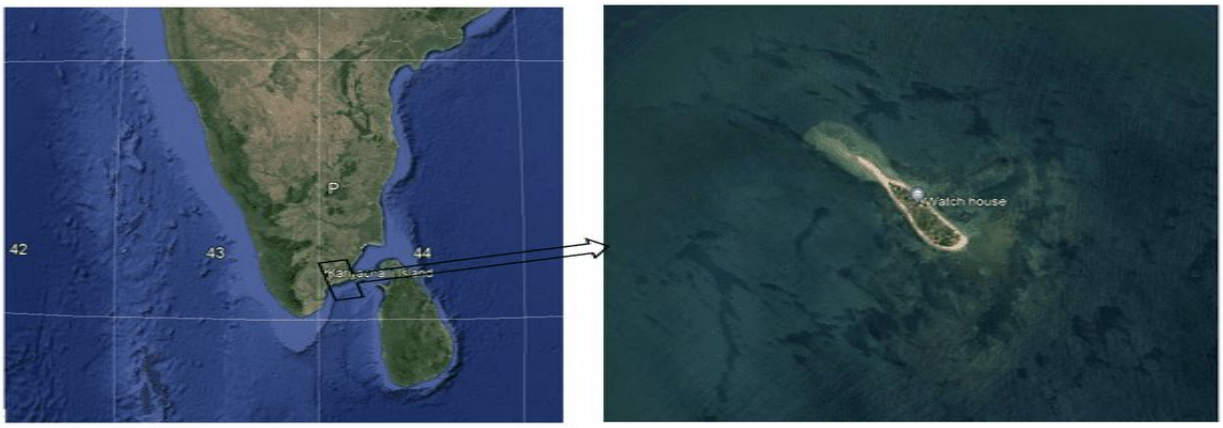


Fig. 1Aerial view of the location

This report presents the details of the behaviour of ocean waves in the vicinity of the Kariyachalli Island. An analysis of the wave climate in this region is required in order to plan and prescribe suitable protection measures. For this purpose, a numerical model which solves the mild slope equation is applied in order to identify the salient offshore points near the islands, where, the wave energy is concentrated due to the combined effect of wave refraction and diffraction.

Scope

- To study the wave dynamics around the Kariyachalli Island to evaluate the region of protection required
- To propose artificial modules to protect the Island from further degradation.
- Design of artificial reef.

Bathymetry

The bathymetry for the island is given by the Tamilnadu forest department as shown in the Fig.2.

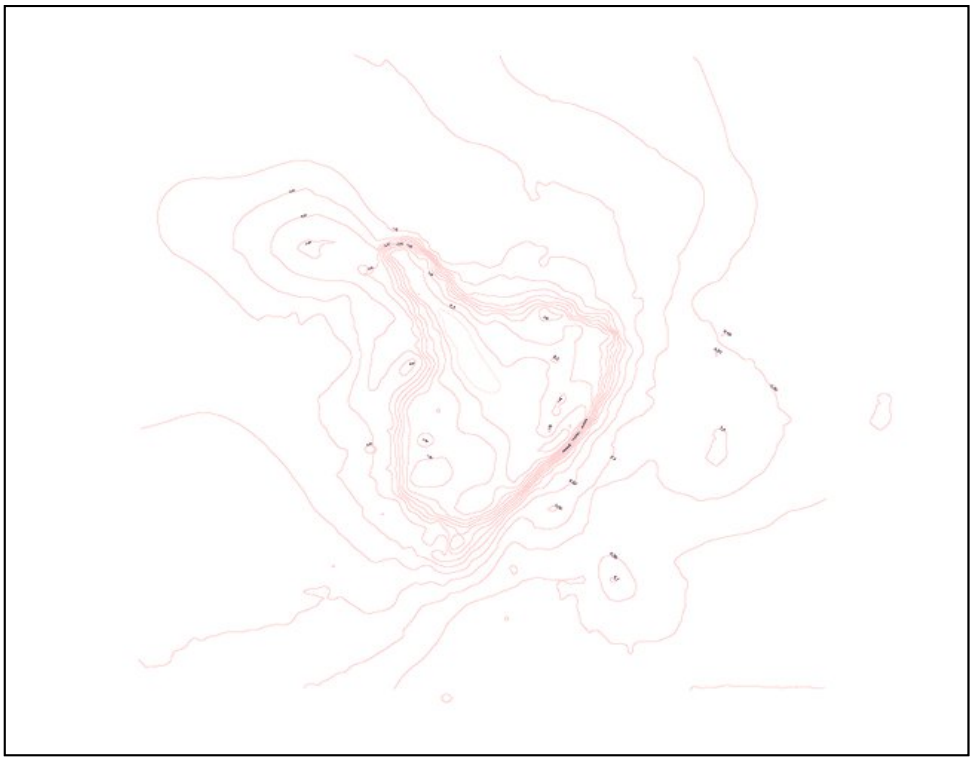


Fig. 2. Bathymetry

Offshore wave characteristics

The wave characteristics such as significant wave height, mean wave period and mean wave direction at a deep-water location (9°00'00.00"N, 78°05'0.00"E) off Kariyachalli Island have been extracted at every 6 hours interval from the European Centre for Medium-Range Weather Forecasts (ECMWF). Basically, the wave field follows the wind pattern. It is noted that the spatial variability is closely related, the maximum H_s are associated with maximum wind speeds. The annual percentage of occurrence of significant wave height is presented in **Fig.3.** It is observed that the offshore wave climate of Kariyachalli is predominantly from east and south west.

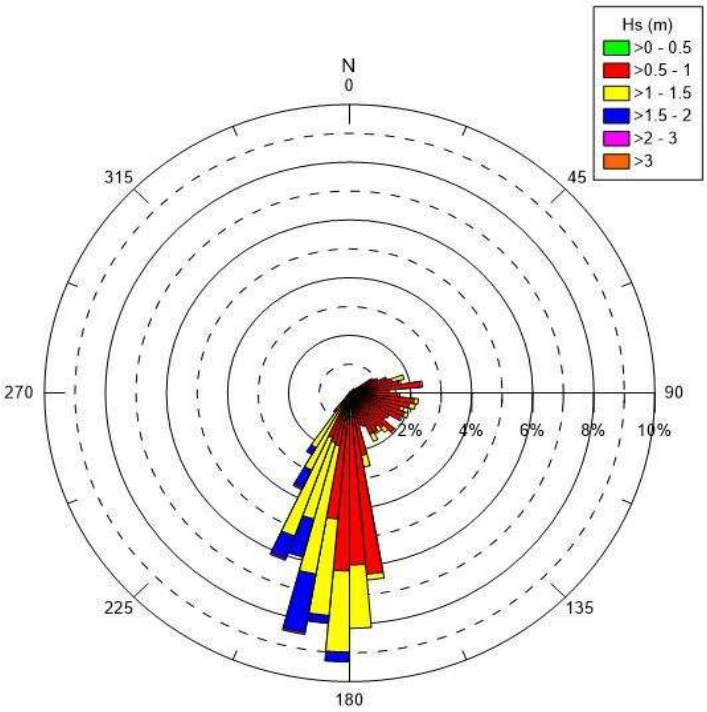


Fig. 3. Wave Rose diagram representing the significant wave height (m) along the direction for an annual year

WAVE MODELLING

4.1 General

The study aims at providing an in-depth analysis on the wave characteristics of Kariyachalli Island.A suitable numerical model is required in order to carry out this task. For the present simulation, the well-known CGWAVE model has been used.

The nonlinear wave propagation associated with most of the observed phenomenon in offshore region (e.g., wave reflection, refraction and diffraction) is generally represented by the shallow water mild slope equation.

$$\tilde{N}.\left(C_p C_g \tilde{N}h\right) + k^2 C_p C_g h = 0 \qquad (4)$$

Where,

C_p and C_g are the wave celerity and group celerity respectively.

η is the water surface elevation.

k is the wave number.

For the computation of near shore wave field, this model (Eqn. (4)) is subjected to the proper boundary conditions. This is provided by the bathymetry and the shore line.

4.2 Computational domain

The computational domain roughly approximates a circle of radius 3.5 km. **Fig.4** shows the domain where the computations are actually performed. The direction of the incident monochromatic wave is defined with respect to the geometric northern direction.

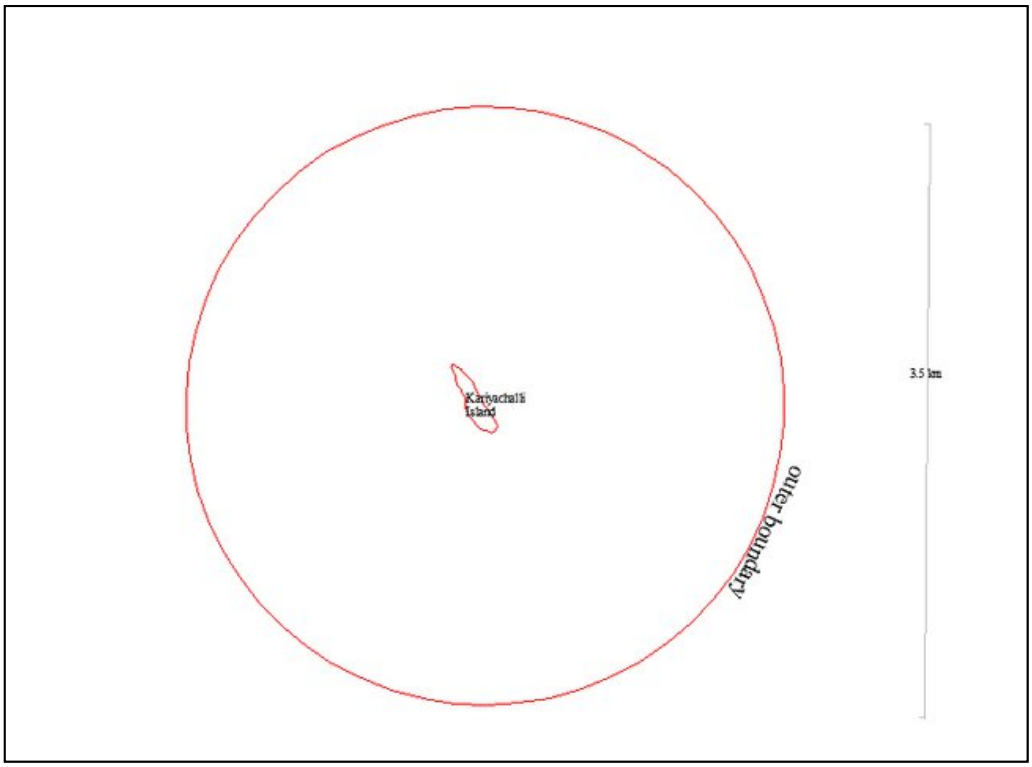


Fig. 4. Computational domain

A numerical method is required to solve the above Eqn. (4) for wave elevation. In this study, Finite Element Method (herein after abbreviated as FEM) is employed. This requires creating a mesh structure in the given computational domain. Upon creation of such a mesh, the domain is represented by nodal points which are connected with each other through the created mesh. The numerical solution of Eqn. (4) is sought in those nodes. This mesh has been generated using the commercial package GAMBIT. The procedure for generation of grid in GAMBIT as follows:

- Based on the region of the sea whose analysis is required add a path in Google earth software.
- Taking the two end nodes of the path draw a semicircle which would represent the domain for which the wave analysis is required.
- Choose the type of elements (tri/quad) and the sizing of mesh.
- Mesh will be generated from which we would be able to know significant wave height and phase at each node.

4.3 Detail of the mesh structure

The CGWAVE model utilizes triangular mesh units in the computational domain. Due to the complexity in the shoreline geometry, an unstructured mesh is desired. Hence a triangular unstructured mesh is generated in GAMBIT, mesh generation software. In such a mesh the nodal spacing is optimized so as to adapt to the nearby portion of the shoreline boundary. The outer circular periphery is modeled by 1571 nodes with a spacing of 5m and the inner shoreline is modeled by nodes with a spacing of 5m. Then an unstructured mesh is created with an average spacing of 5m inside the domain. This leads to a total number of 227949 nodes with 454104numbers of triangular elements. The mesh is shown in **Fig. 5.**

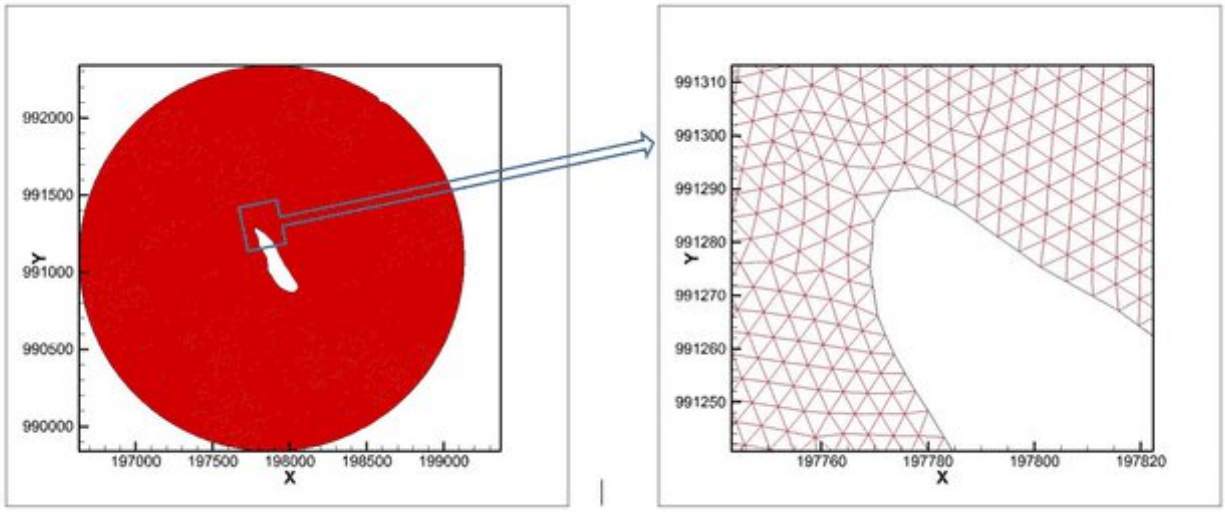
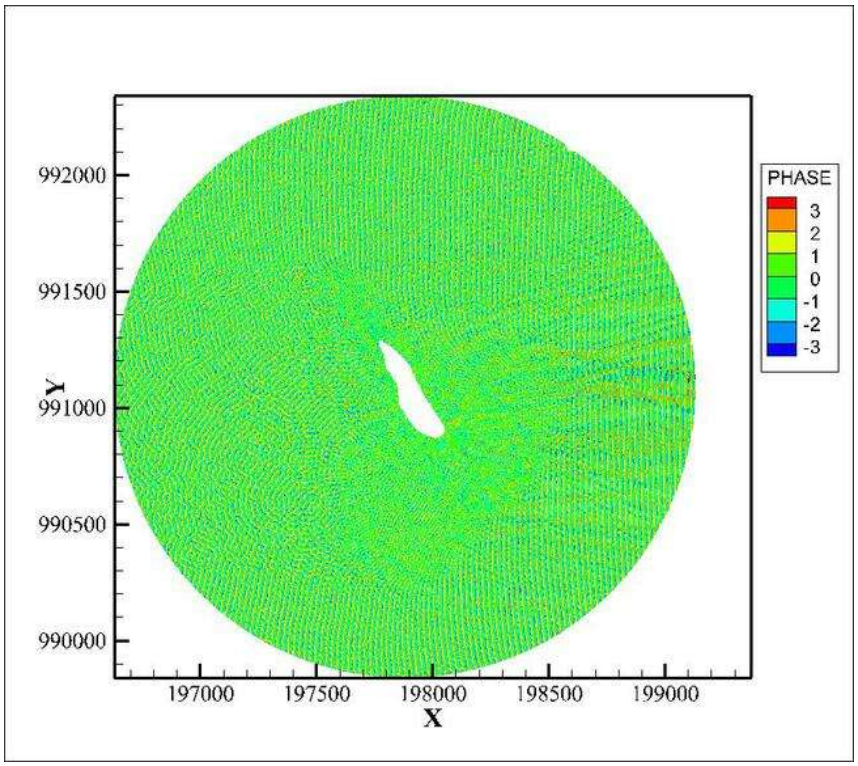


Fig. 5. Mesh Structure adopted for the wave propagation modeling of Island without layout

4.4 Results and discussion

A total number of five wave directions have been simulated in order to investigate the wave tranquilityfor the Island with and without the coral reef protection. The wave directions are chosen such that these represent an annual year. The wave period of the computations is given as 6s-12s to observe the wave climate. The incident wave angle is varied to simulate different wave directional scenarios. The wave climates representing typical wave directions are presented. **Fig.6** to **Fig.10** reports the wave phase diagram and the wave height distribution for different wave approach angles of 90^0,135^0, 155^0, 180^0, 200^0respectively for island



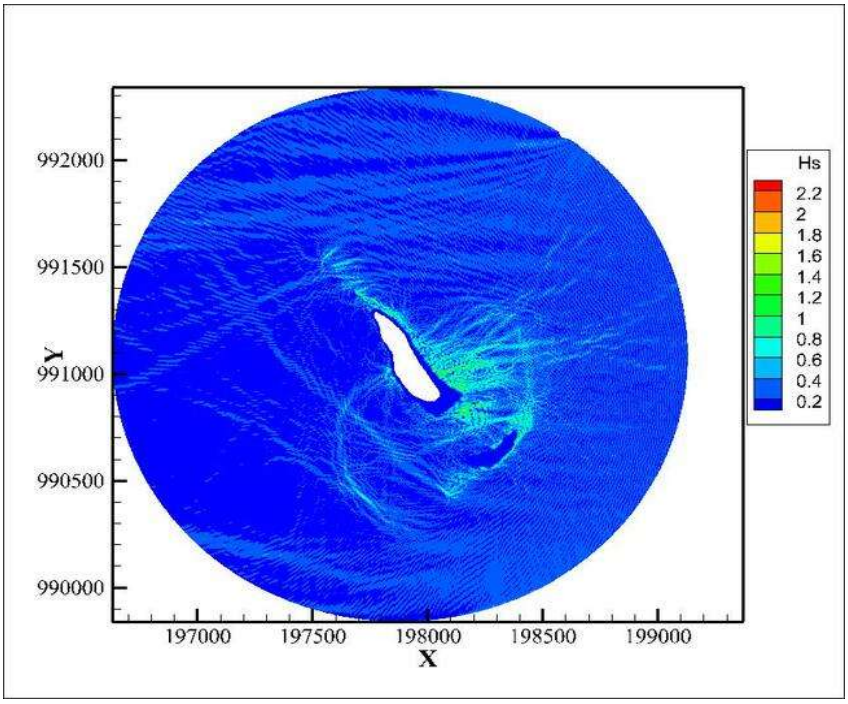
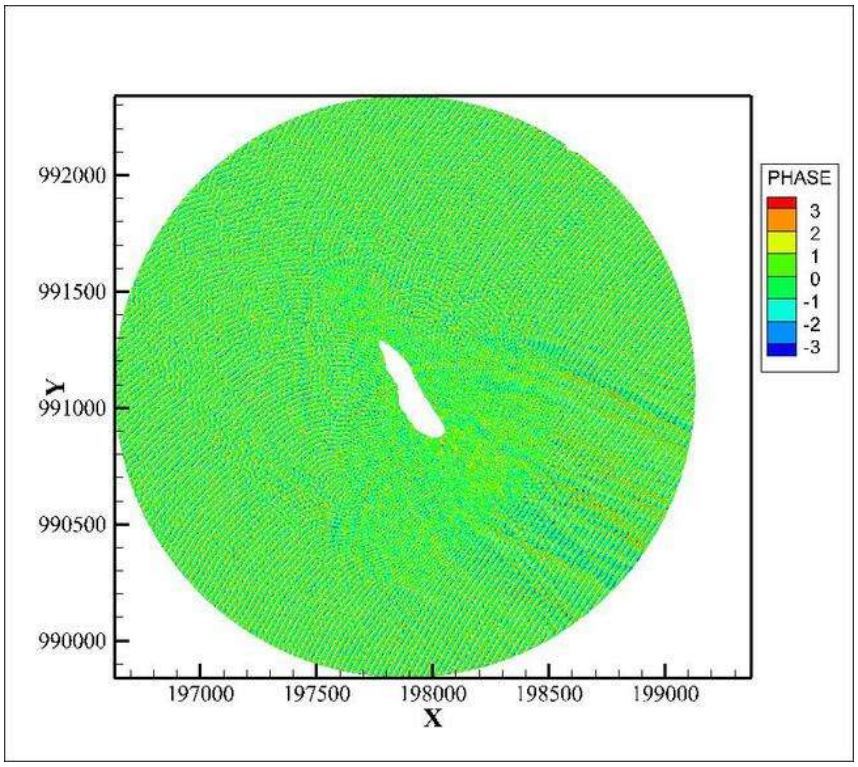


Fig. 6. Phase distributions and Wave height distribution for the wave approach angle from 90^0



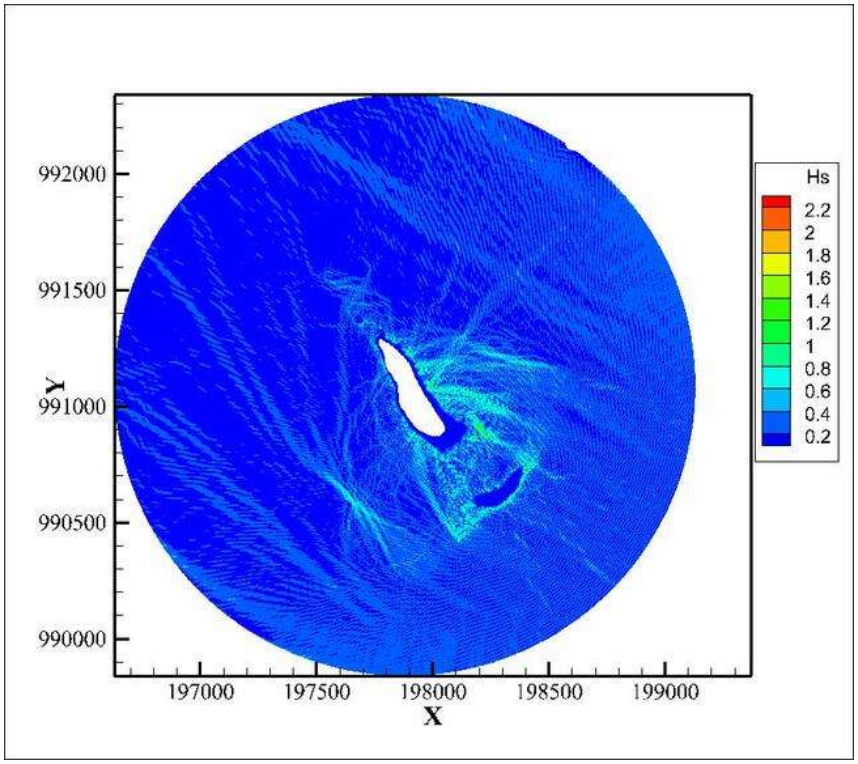
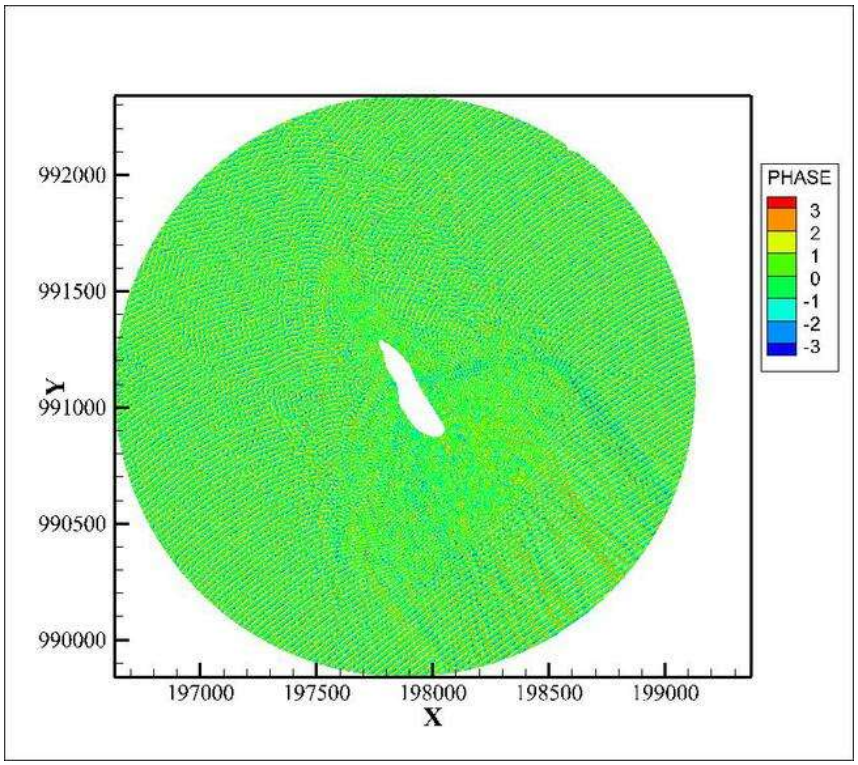


Fig. 7. Phase distributions and Wave height distribution for the wave approach angle from135^0



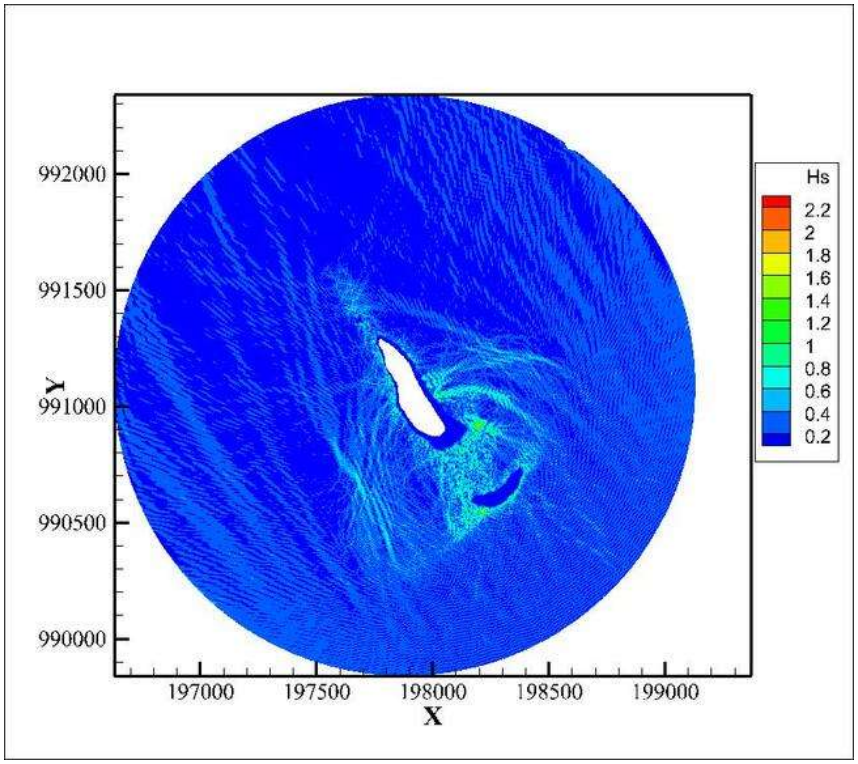


Fig. 8. Phase distributions and Wave height distribution for the wave approach angle from 155^0

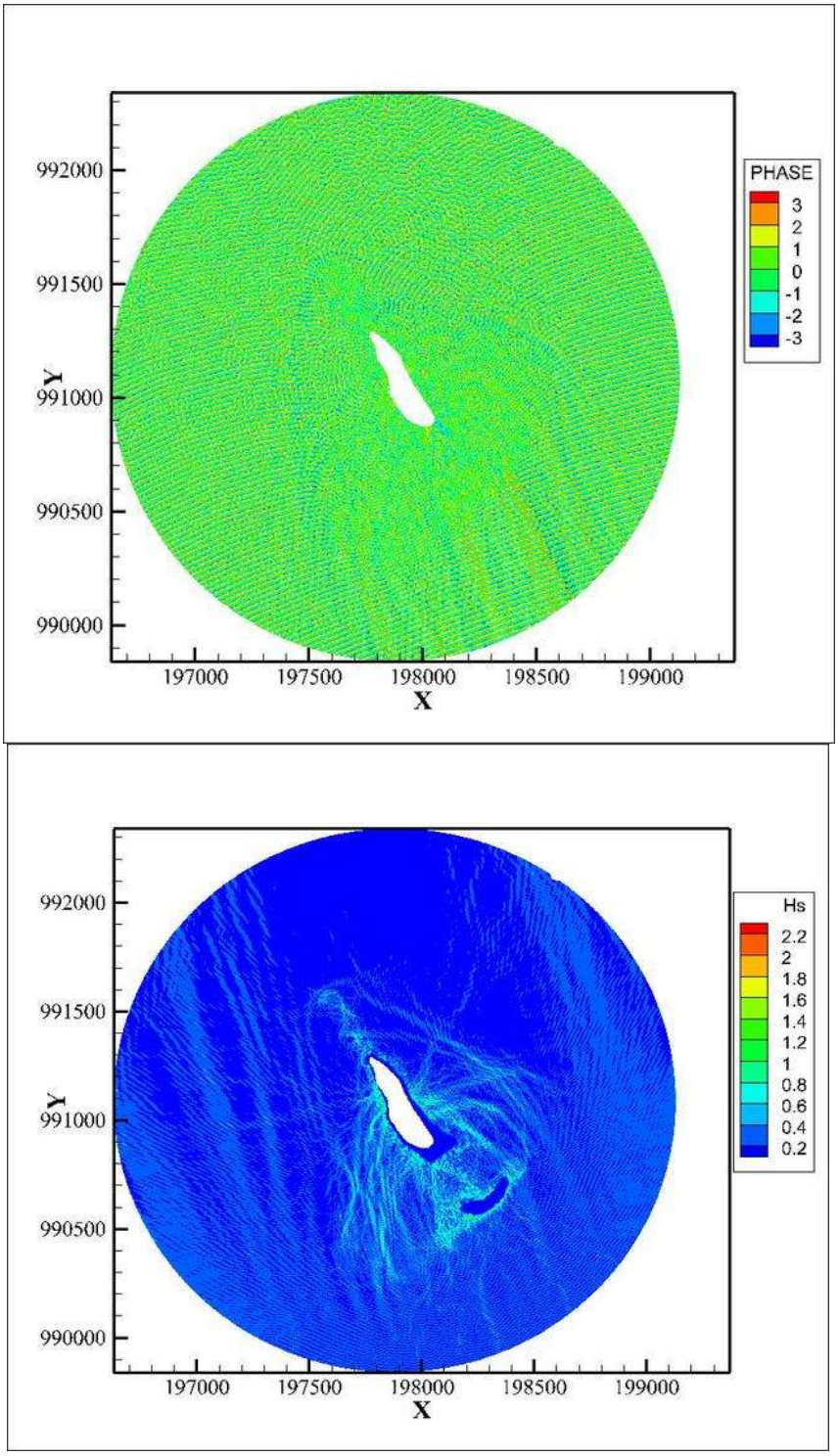


Fig. 9. Phase distributions and Wave height distribution for the wave approach angle from 180^0

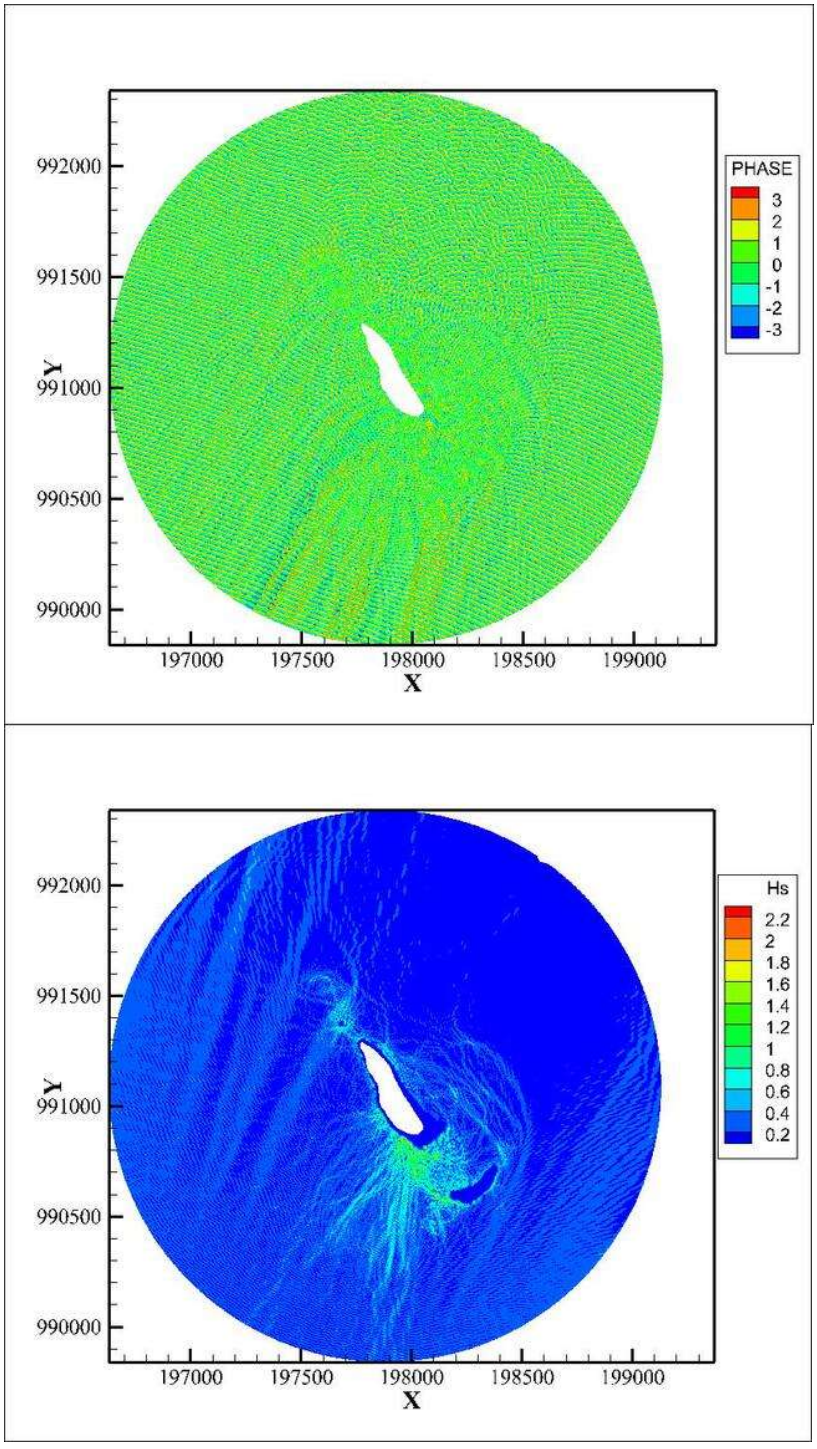


Fig.10. Phase distribution and wave height distribution for the wave approach angle from 200^0

From the above figures, it is understood that the wave concentration is on the south of the island even though there are coral reef protecting the island on the southern side. Hence, it is planned to protect the island from dominant wave action as described in the next section.

Proposed Layout

5.1. Artificial Reef Deployment

Baseline Scenario: Recent survey conducted to assess the status of islands in Gulf of Mannar (Asir et al, 2020) revealed that the islands are facing severe threats from increased climatic and non-climatic factors leading to erosion and submergence. Accordingly, the Kariyachalli Island is expected to submerge before 2036 if the present rate of erosion continues.

Adaptation Activities: The intervention through deployment of multipurpose artificial reef modules will help not only to protect the existing land area of the island but also to increase the land area. The multipurpose artificial reef modules will also help in enhancing biodiversity in particular coral diversity and density and fish production. The design, dimensions and total number of the modules and the location of deployment are based on the outcome of the bathymetry survey and wave dynamics study.

While this method is applied for several purposes such as fishing and recreational activities, in the present instance it should be carried out only for the purpose of rehabilitation and as a climate change adaptation measure, focusing mainly to protect the island. Once the deployment has been carried out, biodiversity in the area will flourish. The activity will also lead to a year-round opportunity for fishing for the fishermen community. The modules are proposed to place continuously within the 3m to 4 m contours at the southeast of the Island to reduce wave intensity. The substrate is made of ferro-cement and reinforcement steel and will attract coral larvae which would get attached to this substratum and grow.

Contribution to climate resilience: The artificial reefs will not only increase the biodiversity in the area, but also protect the island from erosion and submergence due to sea level rise. Further, these areas will provide sustained livelihoods for fishermen.

5.2 Proposed layout

A coral reef protection of approximate 20m width, 850m length continuously along the 2m contour at the southeast of the Island as shown in the Fig. 1. Two types of modules are designed as an artificial coral reef. The dimensions of the modules are 2 m x 2.5m x 1m and 3m x 4m x 1m The typical cross section of the placement is shown in the figure. The layout is kept around 420m approximately from the island. Note that the proposed layout is tentative and it might change according to the site conditions before start of the execution. However, the required number of units are calculated for each type.

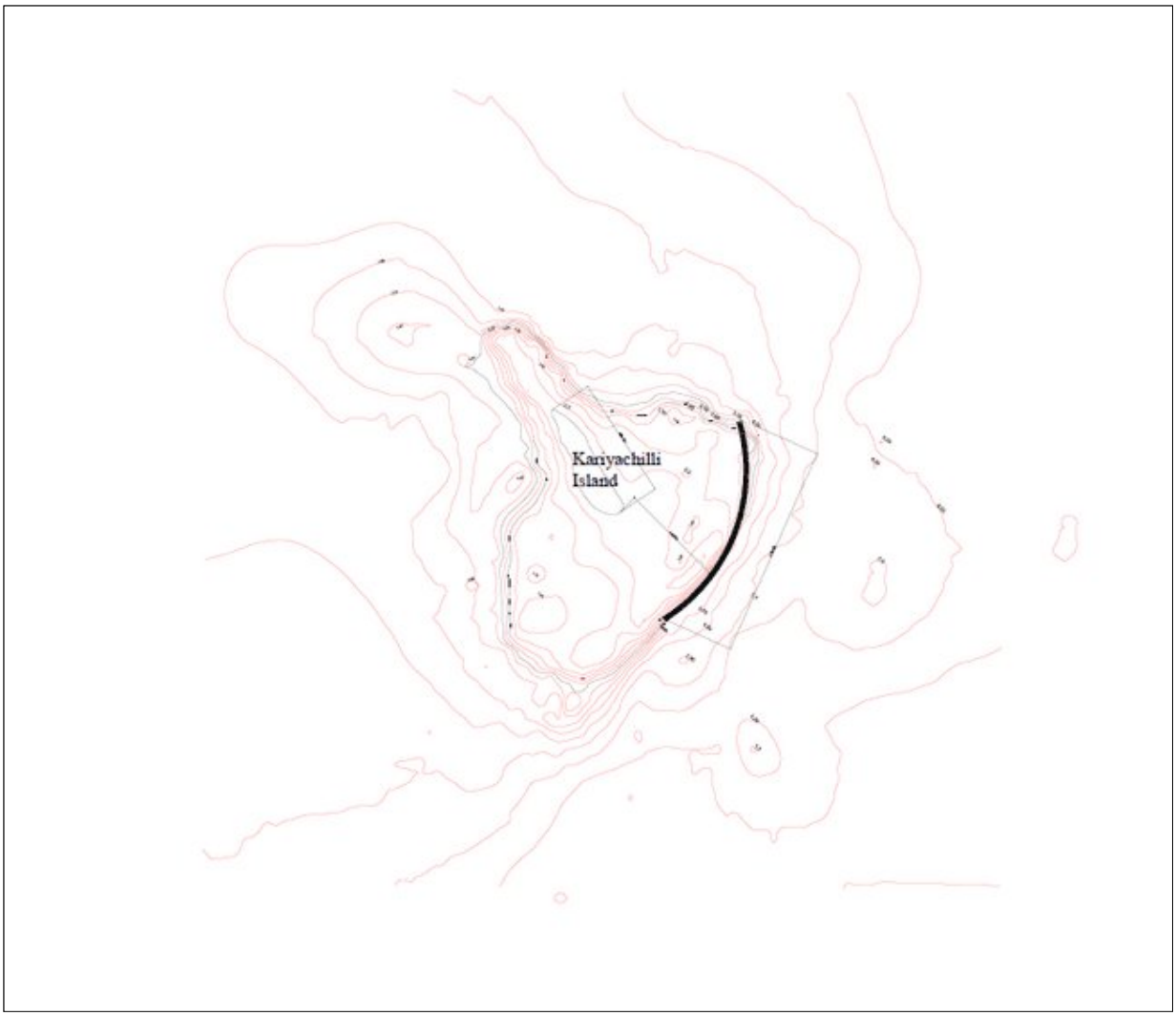


Figure 141 Proposed layout

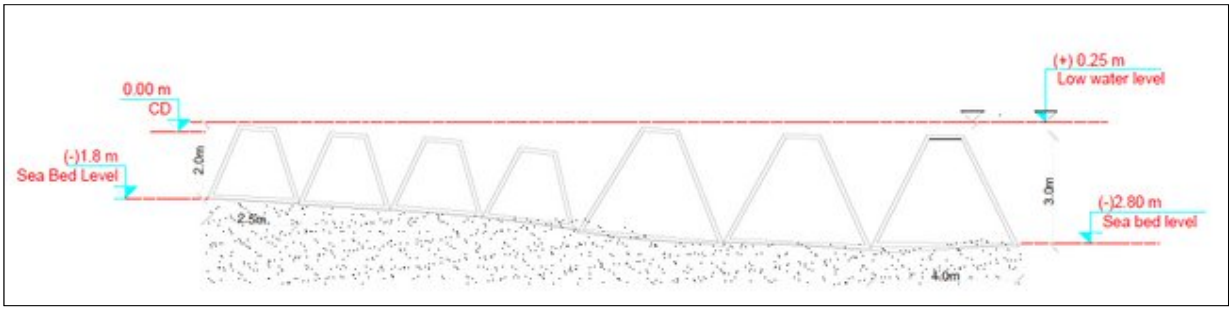


Figure 115 cross section

5.3 Dimensions of the unit

Type 1 module

Height of the Single unit(H)	2	m
Length of the Single unit(L)	1	m

Breadth of the single unit (b)	1	m
Breadth of the single unit (a)	2.5	m
Depth of the slab	100	mm
Volume of a single unit	0.75	m^3

2

2.1.1

Type 2 module

Height of the Single unit(H)	3	m
Length of the Single unit(L)	1	m
Breadth of the single unit (b)	1	m
Breadth of the single unit (a)	4	m
Depth of the slab	100	mm
Volume of a single unit	1.13	m^3

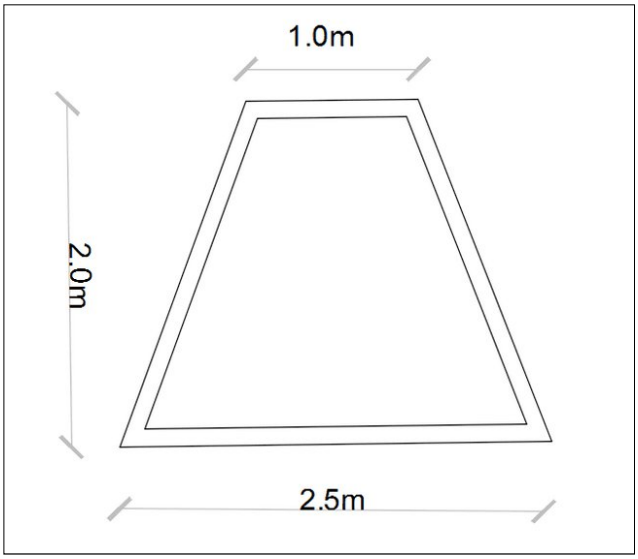


Fig. 11 **Dimension of a single unit of reef(Type 1)**

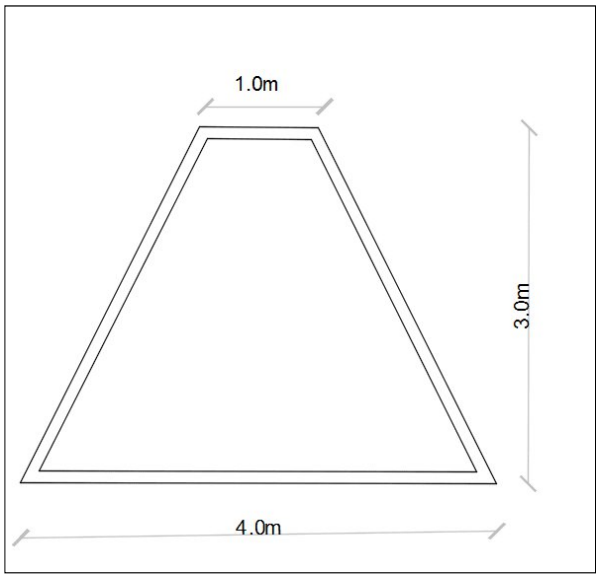


Fig. 12 **Dimension of a single unit of reef(Type 2)**

Results and Discussion

In this report, a detailed numerical investigation has been carried out for understanding the wave dynamics in the marine national park region near Kariyachalli Island.

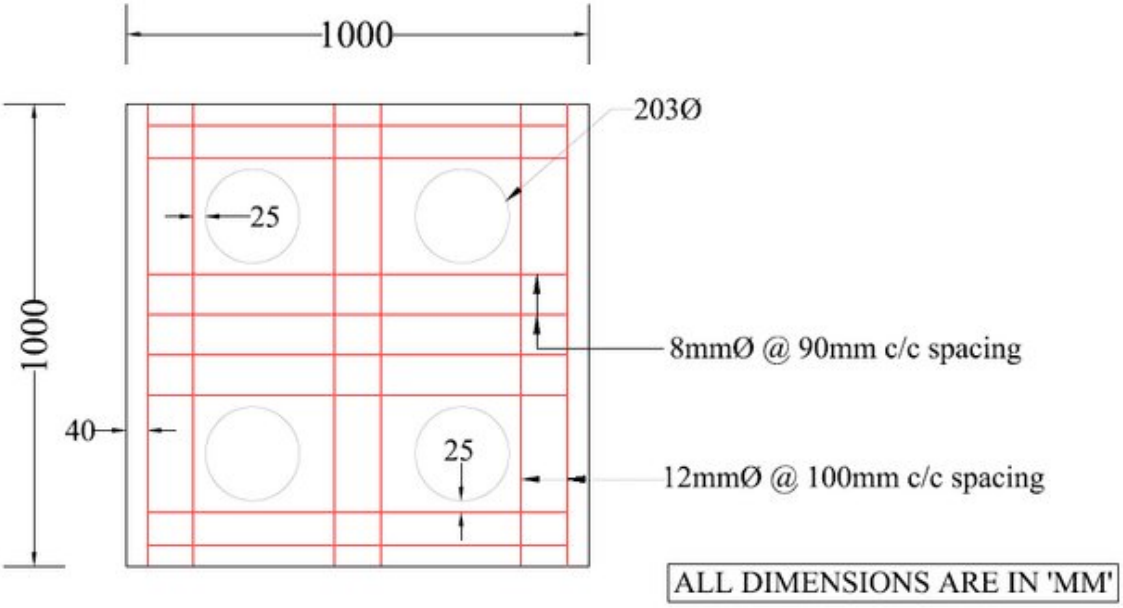
- Based on the wave dynamics study, a suitable protection measure using artificial modules is proposed for the protection of the Kariyachalli Island. The layout consists of continuous reef on the south east of the Island as shown in the Fig.11.

- Based on the proposed layout, the required number of artificial modules of width 4m and height 3m is about 4250 and artificial modules of width 2.5m and height 2m modules is about 4250. As per the wave dynamics, the top clearance (i.e., the water depth during low tide above the artificial module in place) should be of the order of 0.1m to 0.5m below the low tide line. It should also be noted that the artificial modules are porous with sufficient porosity as given in Annexure.

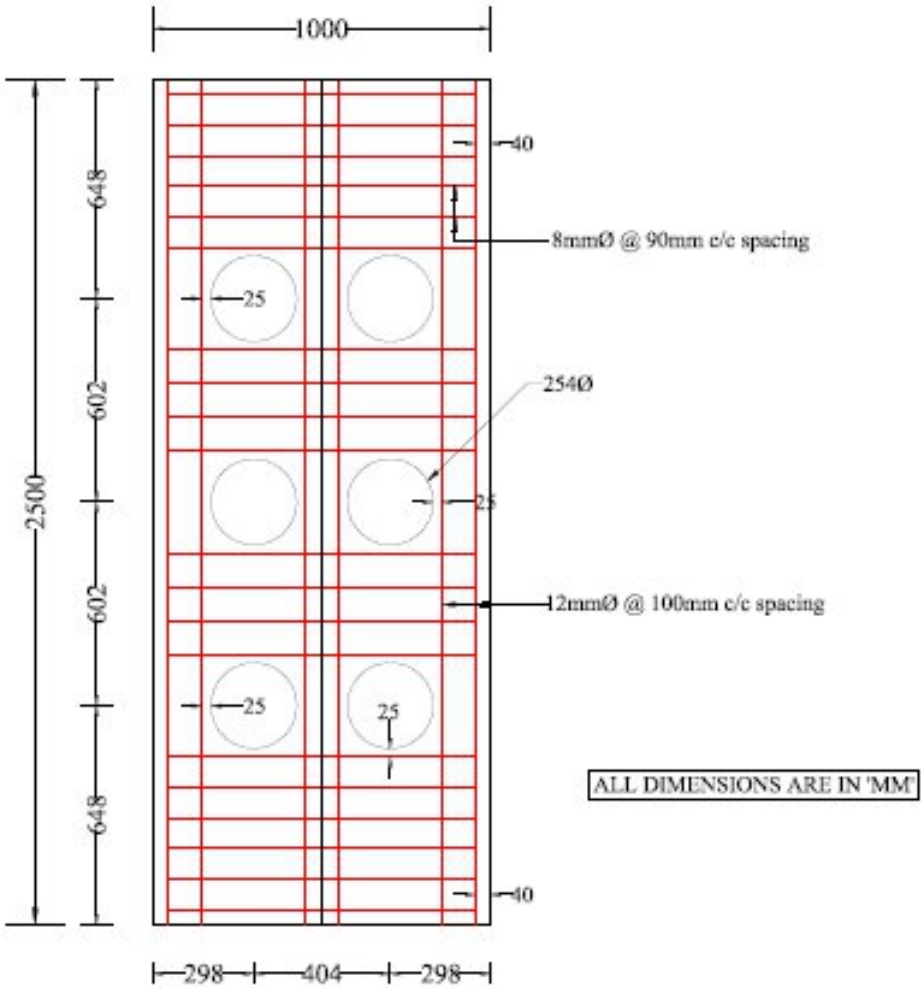
Annexure 1

Reinforcement details of the artificial reef

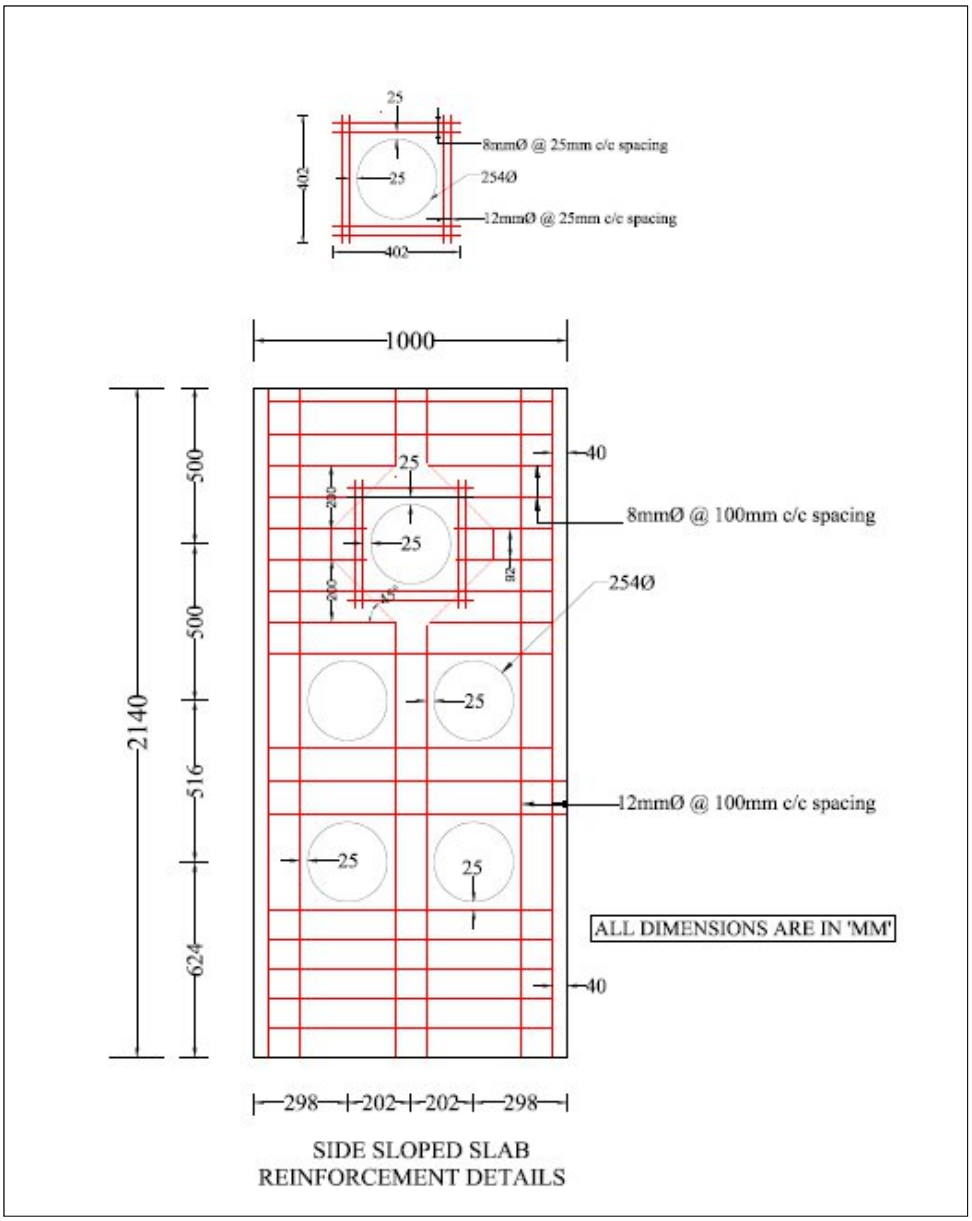
Type 1 module



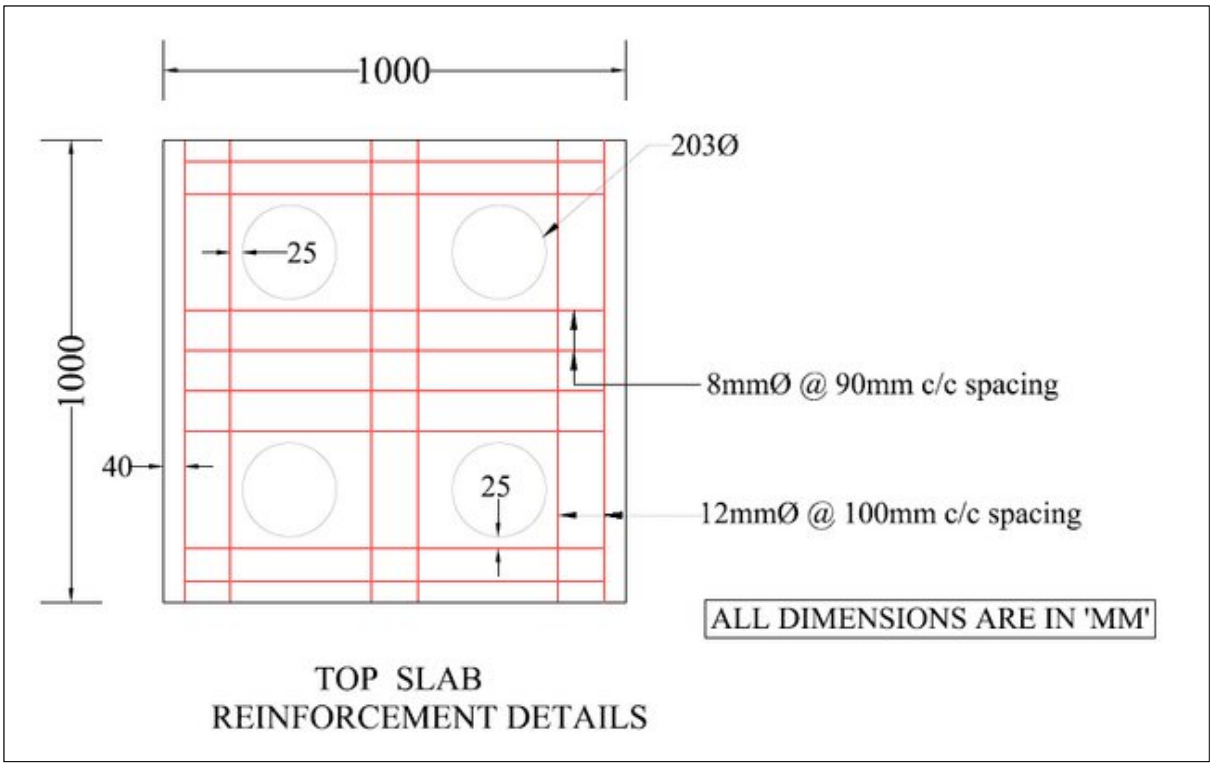
TOP SLAB
REINFORCEMENT DETAILS



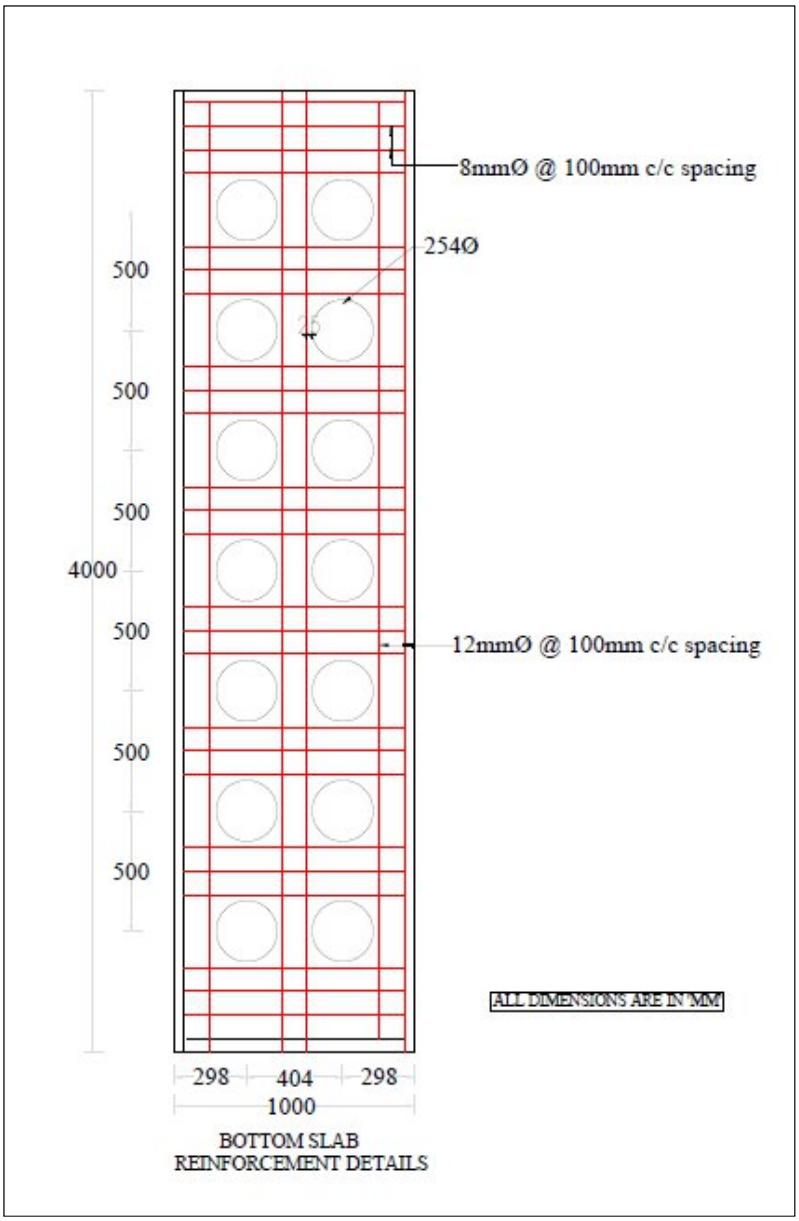
BOTTOM SLAB
REINFORCEMENT DETAILS

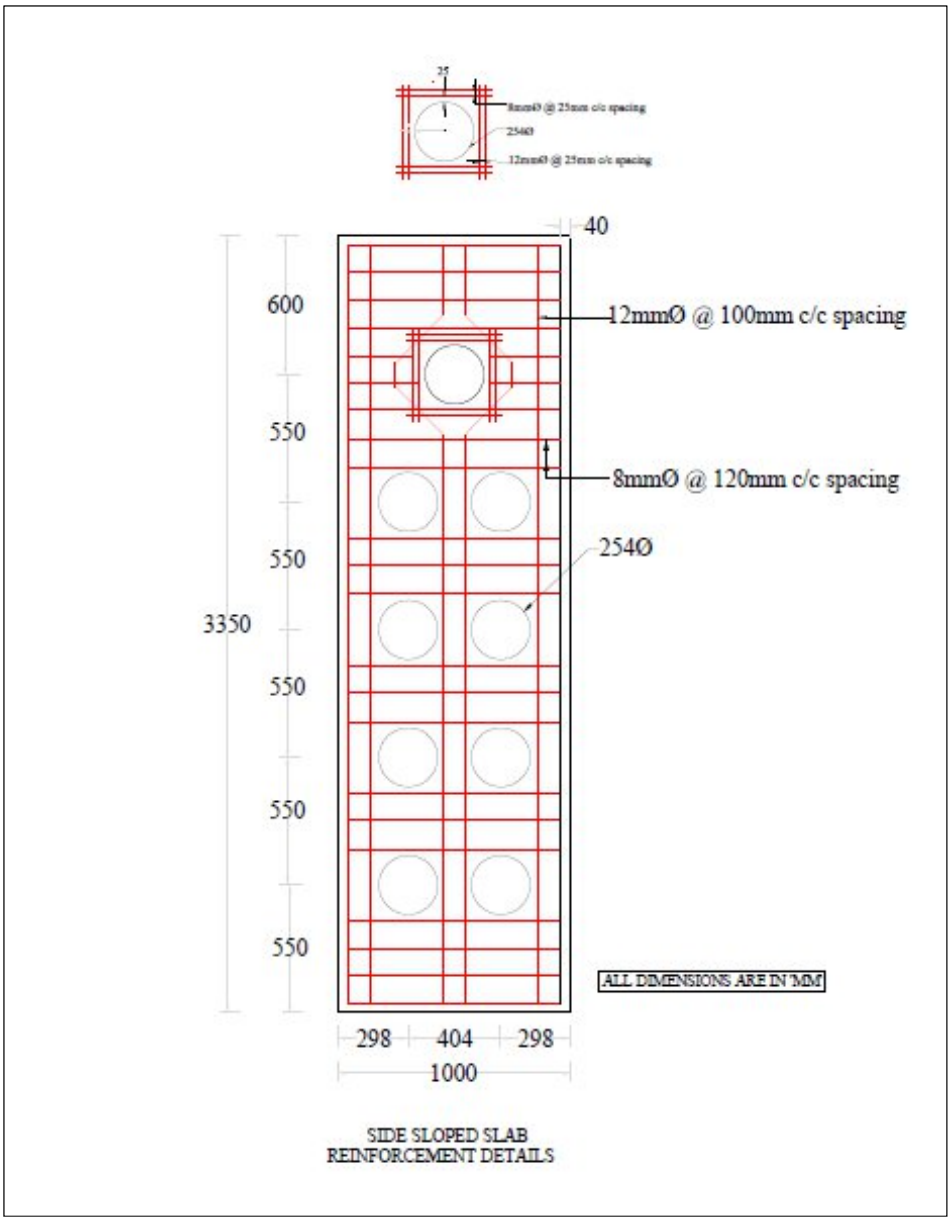


Type 2 module

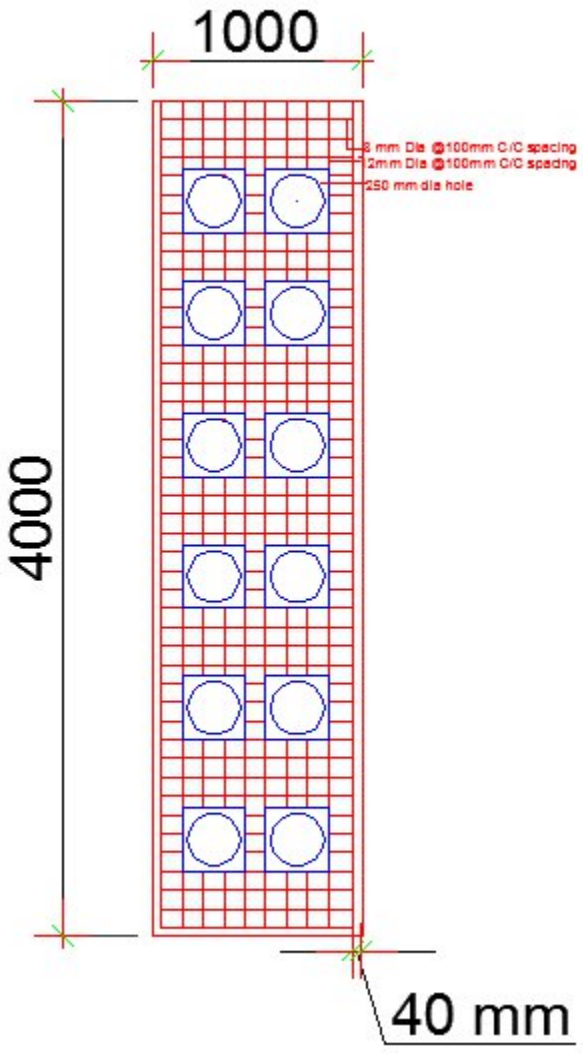


TOP SLAB
REINFORCEMENT DETAILS


8mmØ @ 100mm c/c spacing
25Ø
500
500
500
4000
500
12mmØ @ 100mm c/c spacing
500
500
ALL DIMENSIONS ARE IN 'MM'
298
404
298
1000
BOTTOM SLAB
REINFORCEMENT DETAILS

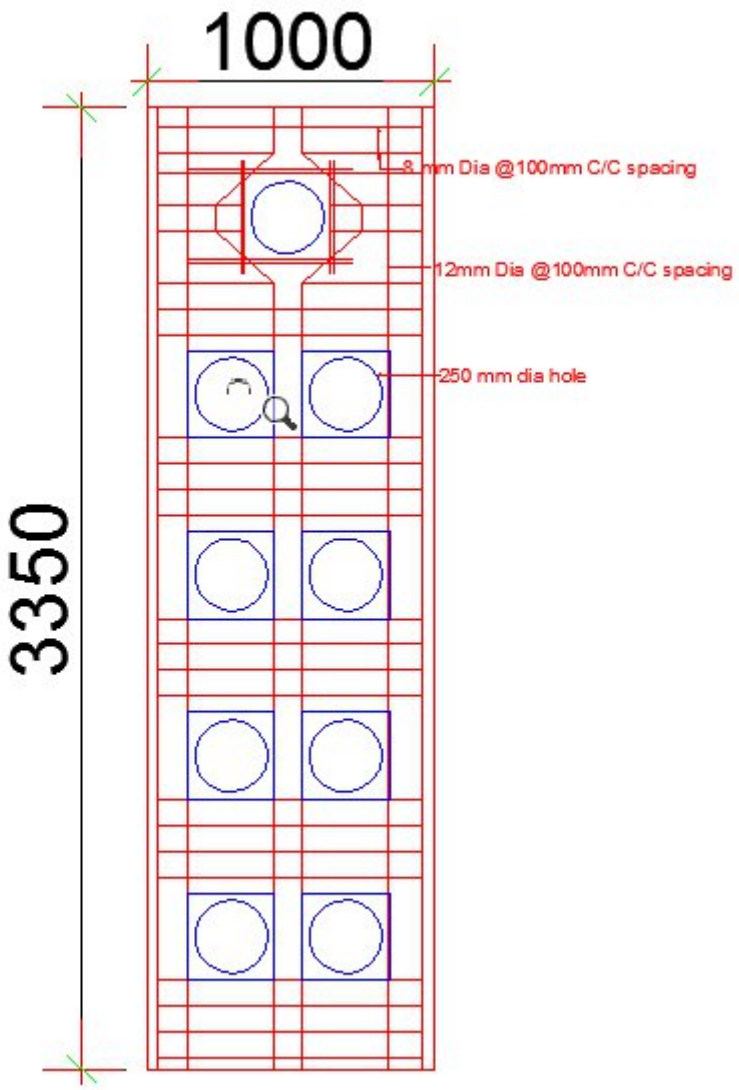


SIDE SLOPED SLAB
REINFORCEMENT DETAILS



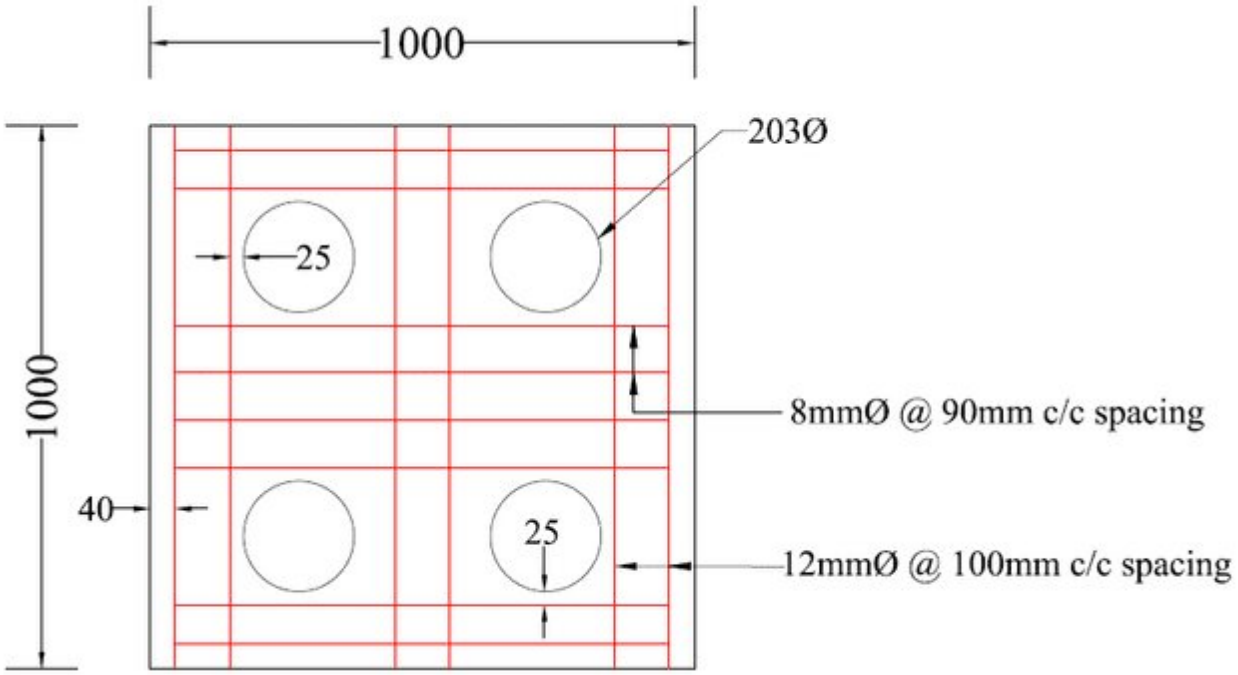
All dimensions are in mm

Bottom Reinforcement



All dimensions are in mm

Side slope Reinforcement



All dimensions are in mm

Top slab Reinforcement

Annexure – 3: Analysis of Impact of AR modules on neighbouring Islands

1.2 Proposed layout

A coral reef protection of 20m width, 850m length continuously along the 2m contour at the southeast of the Island as shown in the Fig. 1. Two types of modules are designed as an artificial coral reef. The dimensions of the modules are 2 m x 2.5m x 1m and 3m x 4m x 1m The typical cross section of the placement is shown in the figure. The layout is kept around 420m approximately from the island. Note that the proposed layout is tentative and it might change according to the site conditions before start of the execution. However, the required number of units are calculated for each type.

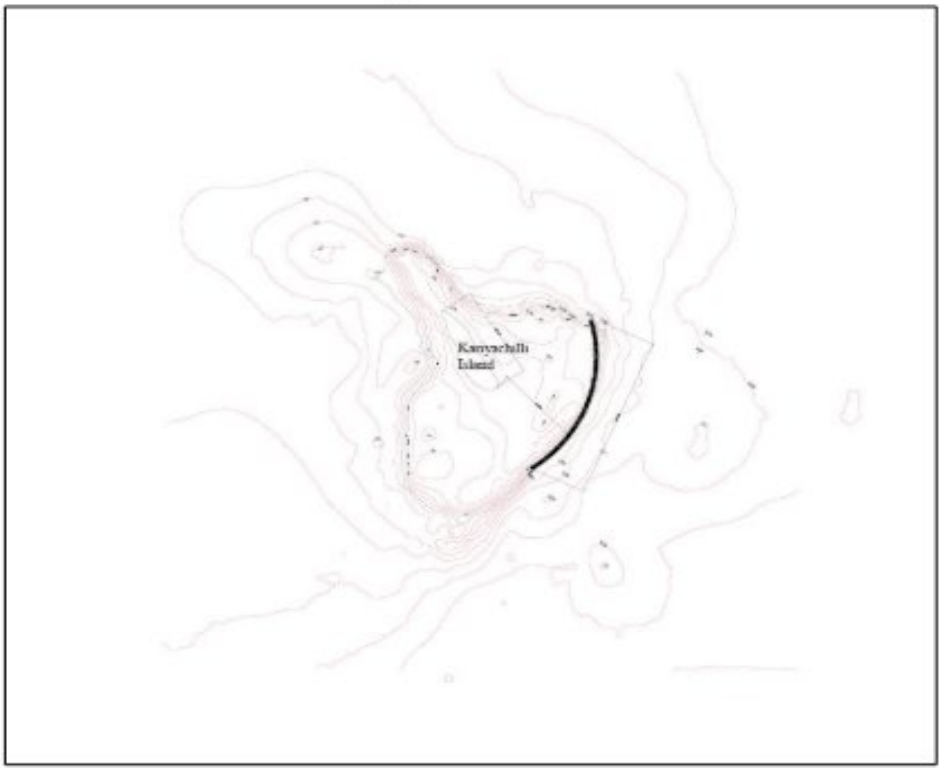


Figure 1 Proposed layout

1.3 Wave Propagation Modelling

After the planning of the proposed layout, it is required to investigate the possible effect of setting up the measure in its place on its neighbouring islands such as the Koswari island.

Hence, the global model encompassing larger region has been setup where both of the Vaan and Koswari islands are kept in their exact relative positions. The details of these test cases are provided for the wave approach angles of 30°, 45°, and 210°. The distance between Vaan and Koswari islands is about 4 km and the disturbance due to neighbourhood was observed to be very less from the wave scattering diagrams of Figs.2 to 4. Further, the distance between the Kariyachalli and Koswari island is about 10km (Fig.6). Hence, the propagation simulation did not show any significant variation with the influence of neighbourhood islands. With this confidence, it is stated that for the proposed intervention of artificial reef south of Kariachalli island would not affect the Koswari island which is south of it.

Further, Figs.7 to 11 show the wave propagation in the vicinity of Karichalli island in the presence of the proposed artificial reef in place. The wave energy from the predominant directions such as east (90°) to south-west and south (180°) has been made to disperse before it reaches the Karichalli island. It would ensure avoiding the further degradation of the island. The entire process of the artificial reef proposal is to avoid further degradation of the island as primary objective. However, it is to be noted that the past island degradation realized the sediment transport around the island only. That is, the past degradation of the island shifted the sediment movement to relatively shallower water depths around the island and in particular, towards the north-west to north-east band since the predominant wave direction is from south to south-east. Hence, it is obvious that with dispersing the wave energy around the island with the introduction of artificial reef, the transported sediment around the island would built up and expected to increase the area of island. This would be secondary advantage of the proposed reef system. In addition, due to increased tranquil condition around the island without affecting the flow conditions, the survivability of corals would increase and hence the fish population would increase.

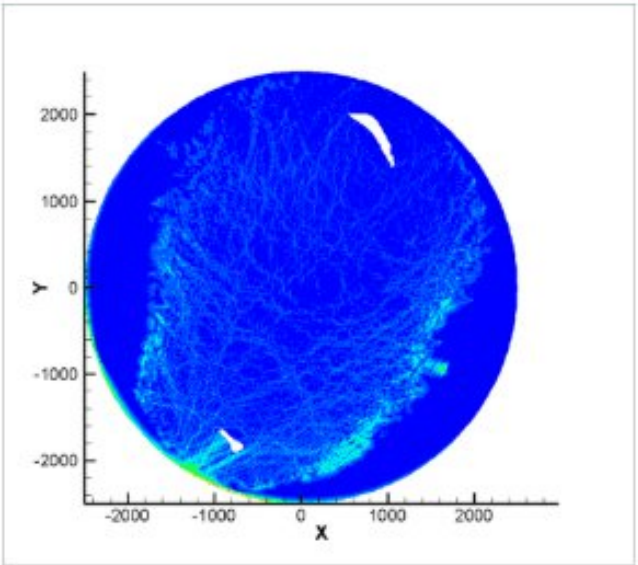


Figure 2 Wave height distribution for the wave approach angle from 30^0

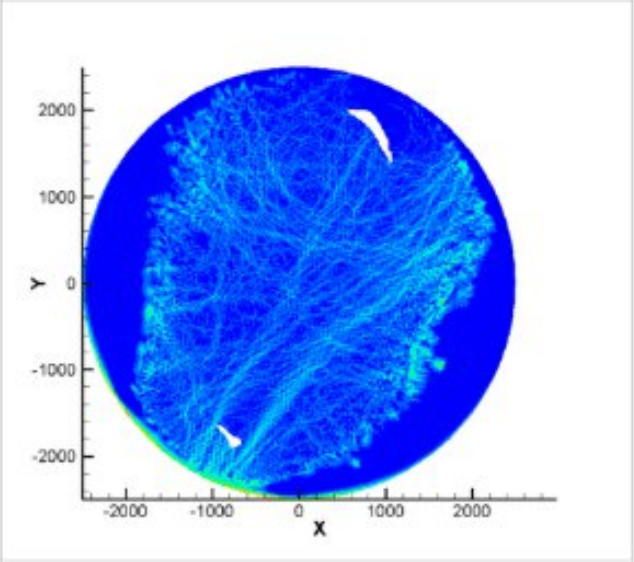


Figure 3 Wave height distribution for the wave approach angle from 45^0

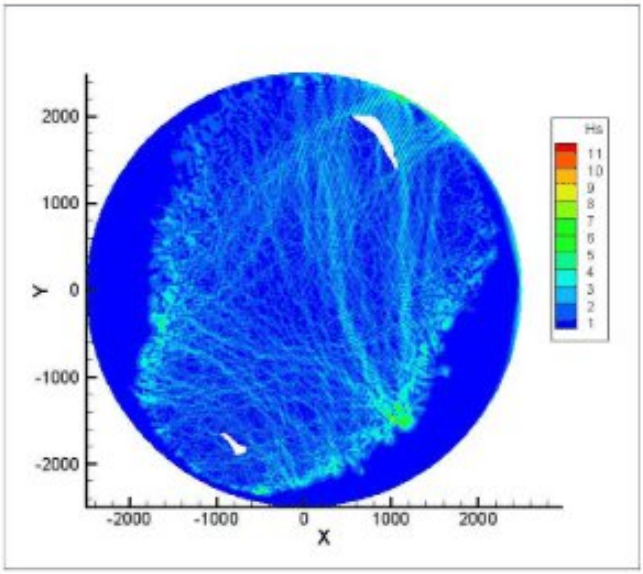


Figure 4 Wave height distribution for the wave approach angle from 210^0

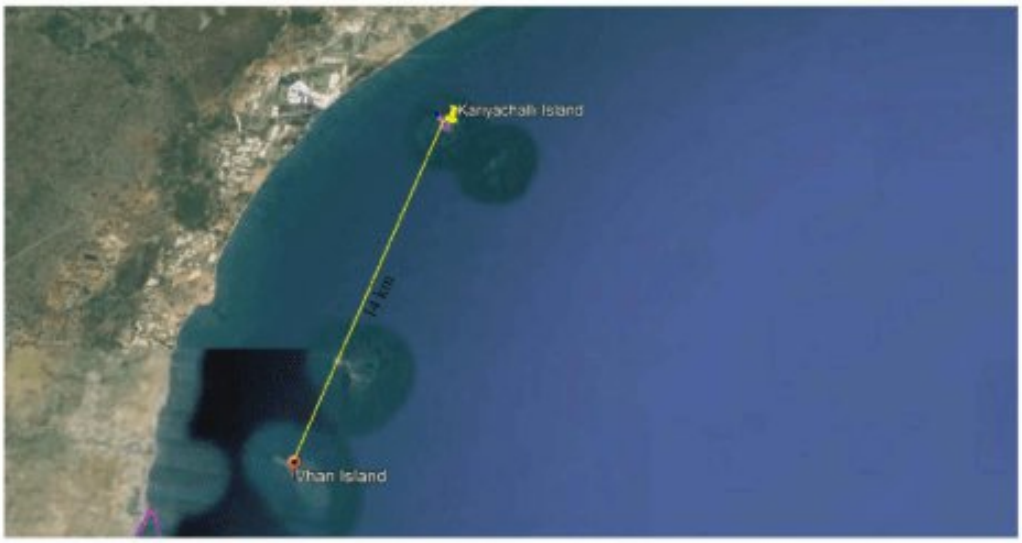


Figure 5 Distance between Vhan Island and Kariyachali Island

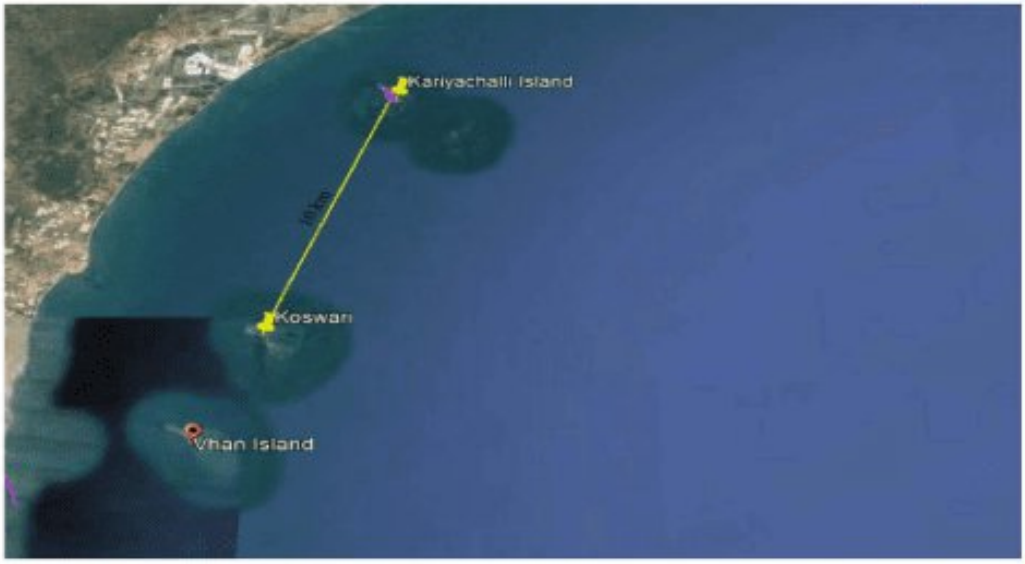


Figure 6 Distance between Koswari Island and Kariyachali Island

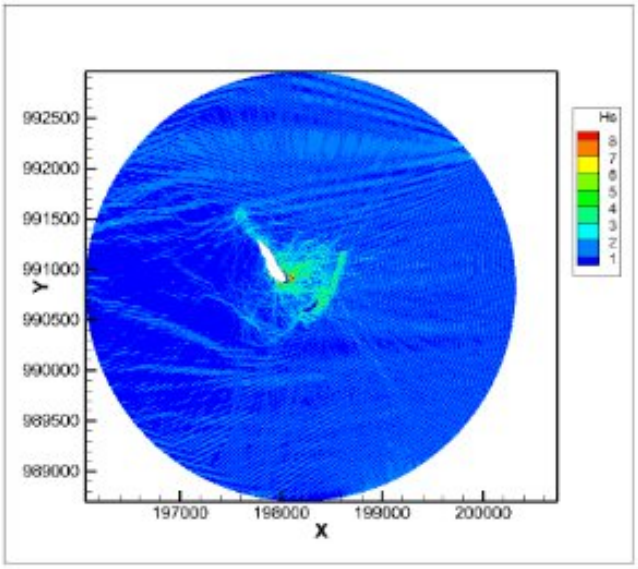


Figure 7 Wave height distribution for the wave approach angle from 90^0 for Kariyachalli Island with Artificial reef

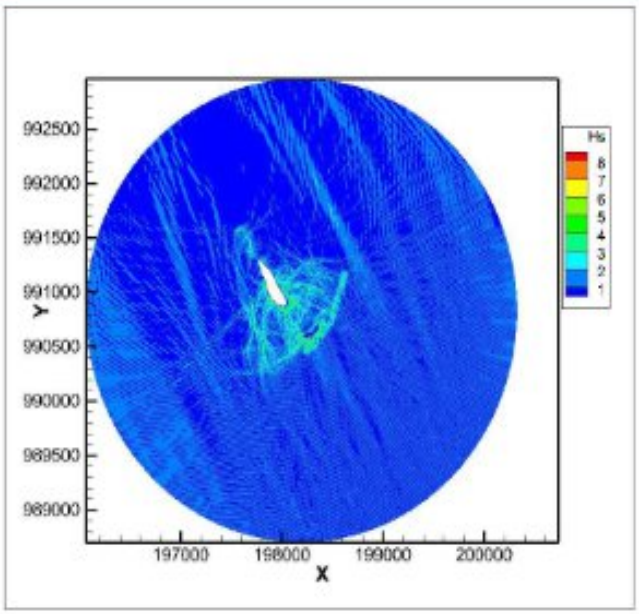


Figure 8 Wave height distribution for the wave approach angle from 135^0 for kariyachalli Island with Artificial reef

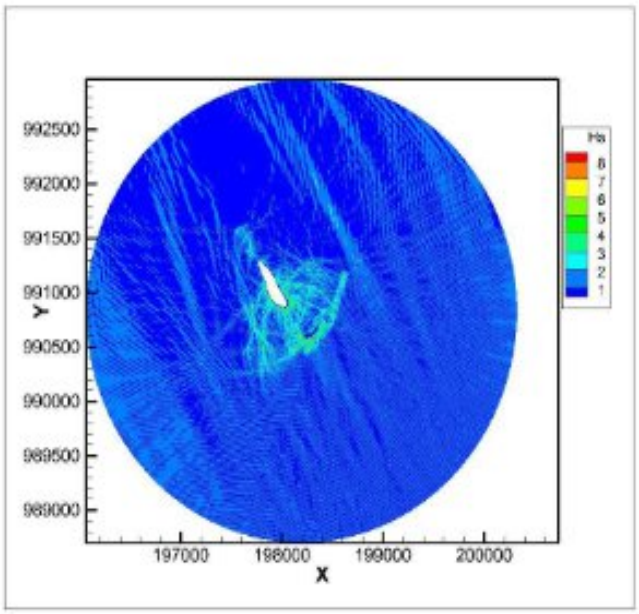


Figure 9 Wave height distribution for the wave approach angle from 155^0 for kariyachalli Island with Artificial reef

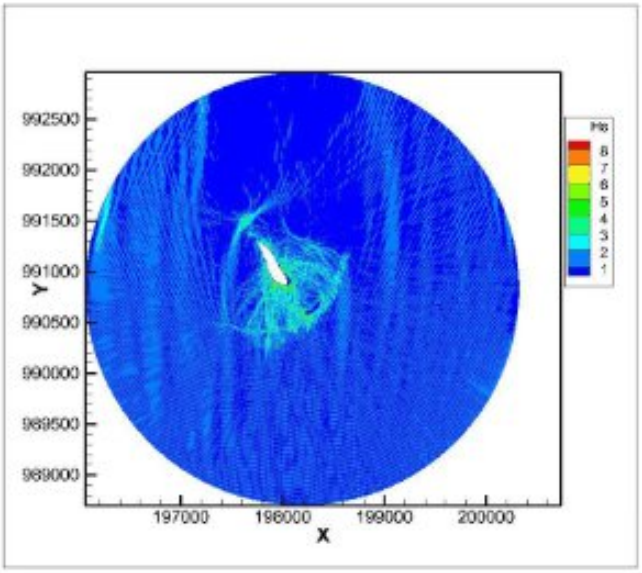


Figure 10 Wave height distribution for the wave approach angle from 180^0 for kariyachalli Island with Artificial reef

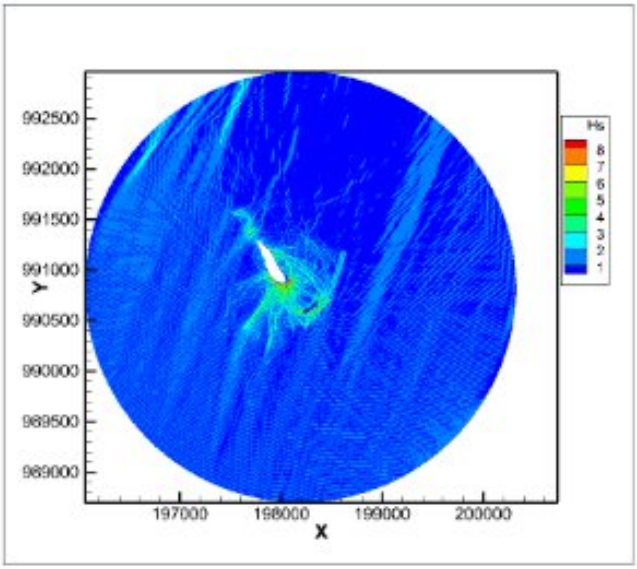


Figure 11 Wave height distribution for the wave approach angle from 200⁰ for kariyachalli Island with Artificial reef

Annexure 4

Questionnaire on Kariyachalli Island restoration project

Ref No:	**Date:**
1.0 Information about the village	
Name of the village :	
Population of fishermen :	
Number of fishermen's societies :	
1.1. **Number of fishing crafts**	
FRP boats :	
Mechanized trawlers :	
Vallams :	
Others :	
2.0 Information about the fishermen	
Name :	
Age :	
Male/Female :	
Address & Contact Number :	
Name of the fishermen's society (If any) :	
Registration number :	
Duration of membership :	
Name of the self-help group (SHG) (If any) :	
Registration number :	
Duration of membership :	
Name of the eco-development (EDC) committee (If any) :	
Duration of membership :	
3.0 Information about fishing grounds/routes	
3.1 Are you involved in fishing near Kariyachalli Island?	
3.2 If yes, where exactly?	
3.3 Do you have GPS coordinates of the sites you fish? If yes, provide them.	
3.4 If no, provide the approximate distance/direction of your fishing grounds from the Island	
3.5 What are the fishing routes you use near the Island?	
3.6 How often do you used these routes?	

Date: Signature:

Annexure – 6: Environmental and Social Risk Screening

1. Sub-project screening procedure

The subproject screening is undertaken following a three-step screening methodology as described in ESMF. The process of risk /impact identification is done using a screening process considering the proposed interventions using the first screening format (SF-1). Each activity is reviewed for the likely risks and impacts. The SF-1 format is used to ascertain the types of E&S risks for each of the proposed activities e.g. Risk/Impact on Land, Geology & Soil (LGS); Water (W), General Ecology & Biodiversity (EB); Waste, Pollution & Hazard (WPH); Protected Area (PA); Land Acquisition/ encroachment, etc. (LA); Loss of Livelihood/ Household, etc. (LL); Labour (L); Occupational Health and Safety (OHS), Culture/Heritage (CH); Tribal Presence (T); GBV Risks (G).

The second screening format (SF-2) is used to assess the extent of risk/impact intensity for each of the identified E&S risks and is used to categorize the risk level as Low/Moderate/Substantial/ High. Finally, using a third E&S risk summary format (SF-3), the risk categories for all different types of E&S risk and impacts is summarized and the highest of the risk categories is assigned as the overall risk category for the sub-project.

The outcome of the stage screening exercise for (i) Deployment of multipurpose artificial reef (AR) modules, (ii) Coral Rehabilitation and (iii) Seagrass Rehabilitation are discussed below.

2. Output 1: Deployment of multipurpose artificial reef (AR) modules

a) Screening Form (SF-1)

Screening indicated that the major field intervention of the proposed sub-project is "**Deployment of multipurpose Artificial Reef (AR) modules**". The objective is to build climate change resilience to the fast eroding Kariyachalli Island through deployment of multipurpose artificial reef modules and to restore ecological services. This will be done by (i) Underwater fixing of AR deployment location (southeast of the Kariyachalli Island) as per the lay out proposed by IIT Madras, avoiding coral area, (ii) Construction of 8,500 multipurpose Artificial Reef modules as per the dimensions proposed by IIT Madras (each with the dimensions of 4.0m width, 3m height and 1 m longitudinal length); (iii) Transportation and deployment of AR modules in the location as per the lay out proposed by IIT Madras and (iv) Monitoring various parameters during and post deployment of AR modules such as Marine water and sediment quality, Coral and seagrass habitats, Island Morphology, Bathymetry and fishery.

The subproject implementation shall have temporary localised environmental impacts which includes (i) Causing disturbance to the seabed by increasing turbidity and suspended solids, which causes viability impact to the marine ecosystem, (ii) generation of noise during loading/unloading of ARs to the site and movement of barge, which will be towed by small vessels, causes temporary noise pollution in the vicinity of the project area, (iii) Some portion of seagrass patches underneath the AR surface might get affected during the AR deployment, (iv) There is a possibility of spilling of waste material into the sea during the transportation of AR units, which could affect the water quality, and can impact both benthic and pelagic biota.(v) Impacts on labor and community health due to poor Labor camp & facilities during fabrication of AR modules.

Considering these Risks/ Impacts, the likely physical impacts will be on the Land and Soil (during the AR fabrication works), Marine water, Ecology & Biodiversity, Waste, Pollution & Hazard, and Protected Area. The activities will be within the Marine environment and hence, no land acquisition or eviction of encroachment is envisaged. However, the project activities involve the engagement of skilled laborers and divers in limited numbers during the deployment of AR units in the identified locations. The SF-1 screening output is given in the **Table 1**.

Table 1: Form SF-1 (Output 1)

Sl.no	**Sub-Project Component**	**Likely Nature of Risk/Impact** (Land, Geology & Soil (LGS); Water (W), General Ecology & Biodiversity (EB); Waste, Pollution & Hazard (WPH); Protected Area (PA); Land Acquisition/ encroachment etc. (LA); Loss of Livelihood/ Household etc. (LL); Labour (L); Occupational Health and Safety (OHS) Culture/Heritage (CH); Tribal Presence (T); GBV Risks (G))
1	**2**	**3**
1	Fabrication of Artificial Reef modules	LGS, W, EB, WPH, L, and OHS
2	Transport of Artificial Reef modules	LGS, W, EB, WPH, PA, L and OHS
3	Deployment of Artificial Reef modules units	W, EB WPH, PA, L and OHS

b) Screening Form (SF-2)

All applicable activities identified as having potential risks/Impacts that were identified through Step I screening, are further screened for associated sub-activity and evaluated for the extent of risk involved using SF-2. The outcome of this screening using SF-2 is given in **Table 2.** Sub-activity's Risk/Impact intensity is further categorised as Low (L), Moderate (M), Substantial (S) or High (H) based on the following criteria:

Low: Localized, temporary, and negligible
Moderate: Temporary, or short-term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non-reversible, long-term, and can only be contained/ compensated

Table 2: Form SF-2 (Output 1)

Sl. No	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
1	**2**	**3**	**4**	**5**
1	Fabrication of AR modules	LGS, W, EB, WPH, L, and OHS	• Impacts on labor and community health due to poor Labor camp & facilities during Fabrication of AR modules • OH&S risks to the labours during the fabrication works, transportation and deployment	LGS - M W - L EB - L WPH - M L - M OHS - M

Sl. No	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
1	**2**	**3**	**4**	**5**
			of ARs ● Contaminants released to the soil during Artificial Reef construction activities - Adverse impact on soil quality ● Air and noise pollution from Construction Vehicles, Equipment and Machinery ● Storage of construction wastes - Soil and water pollution	
2	Transport of Artificial Reef modules	W, EB, WPH, PA, L and OHS	● There is a possibility of spilling of waste material into the sea. This could affect the water quality, which can impact both benthic and pelagic biota. ● Vessel strike of marine fauna – possible Injury to marine fauna (dugongs, turtle, dolphin), Possible oil leak while navigating, Possible injuries to human while loading and unloading of AR modules ● Impact on biodiversity by the barge	LGS - L W - M EB - M WPH - M PA - M L - M OHS - M
3	Deployment of Artificial Reef modules units	W, EB WPH, PA, L and OHS	● Disturbance of the seabed, causing a slight increase in turbidity and suspended solids, will occur during the deployment of ARs ● Noise generated will be those from a single mechanical derrick crane or grab used by the barge during deployment of the ARs ● Accidental risk during ARs deployment ● Loss of benthic organisms due to partial masking of seabed occupation by 8500 AR modules	W - M EB - S WPH - M PA - S L - M OHS - M

Criteria for Risk Evaluation:

Low: Localized, temporary and Negligible
Moderate: Temporary, or short term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non- reversible, long term and can only be contained/compensated

Based on considerations of all the above, the summary of Risk is given in **Table 3**.

Table 3: Summary of Risk and Impacts (SF-3) for Deployment of AR modules

Sub-Project Activity	Environment Risks							
	Land, Geology & Soil	Water	Biodiversity & Host Community	Waste, Pollution & Hazard	Protected Area (WLS, National Park etc.)	Land	Loss of Livelihood/ HH etc.	Lab
Fabrication of Artificial Reef modules	M	L	L	M	None	None	None	M
Transport of Artificial Reef modules	L	M	M	M	M	None	None	M
Deployment of Artificial Reef modules units	None	M	S	M	S	None	None	M
Overall Environmental Risk is '**SUBSTANTIAL**" due to the project is happening in the sensitive biodiversity and protec have an impact on the seagrass and corals. However the impact is temporary and reversible in nature provided with c classified as "**LOW**".								

1. Coral Rehabilitation

a) Screening Form (SF-1)

Screening indicated that the major field intervention of the proposed sub-project is "**Coral Rehabilitation**". The objective is to restore Habitats (Coral rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy. This will be done through (i) Selection of specific rehabilitation site within the identified degraded coral reef area by underwater survey, (ii) Construction of substrates for fragment transplantation, (iii) Deployment of substrates, (iv) Coral transplantation and (v) Monitoring and maintenance of rehabilitated sites.

The subproject implementation shall have temporary localised environmental impacts which includes (i) Impacts on seawater, especially the creation of turbidity by divers, (ii) Pollution at the construction site due to spillage of materials, (iii) Possibility of accidents at sea and likely disturbance to artisanal fishermen and damage to their nets, (iv) Likely creation of turbidity in the water column, (v) Likely damage at donor reef sites while cutting and plastic pollution due to detachment of nylon ropes, and (vi) Possibility of creation of low-level water column turbidity and coral slabs to mask benthic fauna on the seabed

Considering these Risks/ Impacts, the likely physical impacts will be on the Waste, Pollution & Hazard Protected Area, Occupational Health and Safety, Labour, Loss of Livelihood/ Household etc., General Ecology & Biodiversity. Most of the activities will be within the Marine environment and hence, no land acquisition or eviction of encroachment is envisaged. However, the project activities involve the engagement of skilled laborers and divers in limited numbers during the deployment of concrete frames and small cement slab substrates for coral settlement in the identified locations. The SF-1 screening output is given in the **Table 4**.

Table 4: Form SF-1 (Output 2)

Activity and Environmental aspects	**Likely Nature of Risk/Impact.** Land, Geology & Soil (LGS); General Ecology & Biodiversity (B); Waste, Pollution & Hazard (WPH); Protected Area (PA); Loss of Livelihood/ Household etc. (LL)); Occupational Health and Safety (OHS) Labour (L); Tribal Presence (T);
Selection of rehabilitation site/s by underwater survey and identification of donor sites	PA,OHS
Fabrication of concrete frames and small cement slab substrates for coral settlement	WPH,L
Transport of concrete frames and cement slabs using barges for a distance of 20 km	LL, L, OHS
Deployment of concrete frames on seabed by divers	WPH, EB, OHS
Cutting coral fragments (8-11 cm size) of identified native coral at the nearby identified donor reefs with a maximum	EB, OHS, WPH

Activity and Environmental aspects	**Likely Nature of Risk/Impact.** Land, Geology & Soil (LGS); General Ecology & Biodiversity (B); Waste, Pollution & Hazard (WPH); Protected Area (PA); Loss of Livelihood/ Household etc. (LL)); Occupational Health and Safety (OHS) Labour (L); Tribal Presence (T);
of 3-5% of the colony size and tied firmly with cement slabs (20 cm x 5 cm x1.5 cm) using nylon rope and then tied onto the frames already deployed.	
Placing of cement slabs on the concrete frames deployed on the seabed and coral transplantation on cement slabs	EB, OHS
Restoration process (Monitoring and rectification)	OHS

b) Screening Form (SF-2)

All applicable activities identified as having potential risks/Impacts that were identified through Step I screening, are further screened for associated sub-activity and evaluated for the extent of risk involved using SF-2. The outcome of this screening using SF-2 is given in **Table 5.** Sub-activity's Risk/Impact intensity is further categorised as Low (L), Moderate (M), Substantial (S) or High (H) based on the following criteria:

Low: Localized, temporary, and negligible
Moderate: Temporary, or short-term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non-reversible, long-term, and can only be contained/ compensated

Table 5: Form SF-2 (Output 2)

Sl. no	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
1	**2**	**3**	**4**	**5**
1	Selection of rehabilitation site/s by underwater survey and identification of donor sites	PA, OHS EB	Selection of donor site needs to be done properly as it may impact through creating stress on the existing coral reef habitats due to presence of multiple species and other flora and fauna inhabiting the protected area. Further, there will risk to the safety of the driver when the diving equipment fails or sometimes the diver gets hit by sting rays. Coral reefs are protected. However, the chances of damage to the habitat are low	EB - L PA - L OHS - L

Sl. no	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
2	Fabrication of concrete frames and small cement slab substrates for coral settlement	WPH, L	Fabrication may produce cement wastes at the site but not in significant quantity. Being small structures, the chances of injuries to labour is low	WPH -L L -L
3	Transport of concrete frames and cement slabs using barges for a distance of 20 km	L, LL,OHS	Loading involves labour and chances of injuries. Risk of accidents and run-over fishing nets and damaging it, thus affecting the day's fish catch	LL - L OHS – M L - L
4	Deployment of concrete frames on seabed by divers	EB, WPH, OHS	Loss of sessile and sedentary benthic fauna due to masking of the seabed with creation of turbidity during placement, and safety risk to the diver due to large size of frames	EB - S WPH - L OHS – M
5	Cutting coral fragments (8-11 cm size) of identified native coral at the nearby identified donor reefs with a maximum of 3-5% of the colony size and tied firmly with cement slabs (20 cm x 5 cm x1.5 cm) using nylon rope and then tied onto the frames already deployed.	OHS, WPH, EB	Risk of diving and replacement of undergrown transplants causing turbidity in the water column and possibility of pieces of nylon ropes detached from frames causing low level of pollution	OHS – M EB -M WPH -L
6	Placing cement slabs on concrete frames and coral transplantation on cement slabs	OHS, EB	Risk to diver due to chances of failure of diving equipment as diver remains in the sea for a long time. Complete masking of benthic fauna living on seabed	OHS – L EB - S
7	Restoration process (Monitoring and rectification)	OHS	Removal of slabs with no coral settlement if no benthic animals are settled	OHS -L

Criteria for Risk Evaluation:

Low: Localized, temporary and Negligible
Moderate: Temporary, or short term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non- reversible, long term and can only be contained/compensated

Placement of concrete frames on the seafloor and cement slabs over it to facilitate coral growth completely masks the seabed severely affecting the bottom fauna living in the area. There would be a permanent loss of fauna. However, some of the sessile and sedentary organisms may settle on the cement slab itself, but not to a large extent. Hence, the intensity of impact is categorized as **Substantial**.

Table 6: Summary of Risk and Impacts (SF-3) for coral reef restoration

	Environmental Risks						
Activity	**Land, Geology & Soil**	**General Ecology & Biodiversity**	**Waste, Pollution & Hazard**	**Protected Area (WLS, National Park etc.)**	**Land**	**Labour**	**Loss of Livelihood HH etc.**
Selection of rehabilitation site/s by underwater survey and identification of donor sites	None	L	None	L	None	None	None
Fabrication of concrete frames and small cement slab substrates for coral settlement	None	None	L	None	None	L	None
Transport of concrete frames and cement slabs using barges for a distance of 20 km	None	None	None	None	None	L	L
Deployment of cement frames on seabed by divers	None	S	L	None	None	None	None
Cutting coral fragments (8-11 cm size) of identified native coral at the nearby identified donor reefs with a maximum of 3-5% of the colony size and tied firmly with cement slabs (20 cm x 5 cm x1.5 cm) using nylon rope and then tied onto the frames already deployed.	None	M	L	None	None	None	None
Placing cement slabs on concrete frames and Coral transplantation on cement slabs							
Restoration process (Monitoring and rectification)	None	None	None	None	None	None	None
Overall risk is **SUBSTANTIAL** due to the complete masking of the seabed by concrete frame and cement slabs leadin the seabed.							

1. Seagrass Rehabilitation

a) Screening Form (SF-1)

Screening indicated that the major field intervention of the proposed sub-project is "**Seagrass Rehabilitation**". The objective is to restore Habitats (Seagrass rehabilitation) and ecological services in Kariyachalli Island as a climate adaptation strategy. This will be done through (i) Selection of specific rehabilitation site within the identified degraded seagrass area by underwater survey, (ii) Development of transplantation substrate (PVC frame / Coir ropes) (iii) Seagrass shoots transplantation and (iv) Monitoring and maintenance of rehabilitated sites.

The subproject implementation shall have temporary localised environmental impacts which includes (i) Impacts on seawater, existing seagrass habitats and other marine flora and fauna within the Island, (ii) Postponement in obtaining the permits/ clearances/ approvals will delay the work and thereby lead to the increase in the sub-project cost, (iii) Temporary solid waste Pollution impacts on the surrounding area, (iv) Possibility of accidents at sea and likely disturbance to artisanal fishermen and damage to their nets, (v) May create stress if not collected from appropriate donor sites and in a careful manner, (vi) Limited and localized Impact on existing marine habitat, (vii) PVC pollution, (viii) Impact on the marine process due to the deployment of foreign materials (PVC frames) and (ix) Limited impacts on protected marine habitats en route if any during transportation of PVC frames to the site.

Considering these Risks/ Impacts, the likely physical impacts will be on the Protected Area, General Ecology & Biodiversity, Occupational Health and Safety, Waste, Pollution & Hazard, Labour, and Loss of Livelihood/ Household etc. Most of the activities will be within the Marine environment and hence, no land acquisition or eviction of encroachment is envisaged. However, the sub- project activities involve the engagement of skilled laborers and divers in limited numbers during the deployment of PVC frames tied with Seagrass shoots and Transplantation of Seagrass at target sites. The SF-1 screening output is given in **Table 7**.

Table 7: Form SF-1 (Output 3)

Activity and Environmental aspects	**Likely Nature of Risk/Impact.** Land, Geology & Soil (LGS); General Ecology & Biodiversity (EB); Waste, Pollution & Hazard (WPH); Protected Area (PA); Loss of Livelihood/ Household etc. (LL)); Labour (L); Occupational Health and Safety (OHS); Culture/Heritage (CH); Tribal Presence (T);
Planning of Seagrass Restoration and Target Site Selection in the field	PA, EB,OHS
Fabrication of PVC Quadrats	WPH
Transport of PVC quadrats by barge to the site	L, OHS, LL
Collection of Seagrass Shoots from Donor Sites	PA, EB, OHS
Manual Transplantation of sprigs/ Deployment of PVC frames tied with Seagrass shoots in the boat and deploying the frames by the divers at target sites	EB, OHS,WPH
Restoration Process (Monitoring and Maintenance)	OHS, WPH

b) Screening Form (SF-2)

All applicable activities identified as having potential risks/Impacts that were identified through Step I screening, are further screened for associated sub-activity and evaluated for the extent of risk involved using SF-2. The outcome of this screening using SF-2 is given in **Table 8.** Sub-activity's Risk/Impact intensity is further categorised as Low (L), Moderate (M), Substantial (S) or High (H) based on the following criteria:

Low: Localized, temporary, and negligible
Moderate: Temporary, or short-term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non-reversible, long-term, and can only be contained/ compensated

Table 8: Form SF-2 (Output 3)

Sl. No	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
1	**2**	**3**	**4**	**5**
1	Planning of Seagrass Restoration and Target Site Selection in the field	PA, OHS EB	Selection of donor site needs to be done properly as it may impact through creating stress on the existing seagrass habitats and other flora and fauna inhabiting the protected area. Further, there will risk to the safety of the driver when the diving equipment fails or sometimes the diver gets hit by sting rays. Seagrass habitats are protected. However, the chances of damage to the habitat are low	EB - L PA - L OHS - L
2	Fabrication of PVC Quadrats	WPH, L	Fabrication may produce plastic wastes at the site but not in significant quantity and due to the softness of PVC risk of injury to the labour is low	WPH -L L -L
3	Transport of PVC Quadrats by barge to the site	L. OHS, LL	Labours involved in loading and transport mostly remain on the boat with low chances of risk. Possibility of run over fishing nets enroute resulting in damage to the nets and affecting the day's fish catch	L -L OHS-L LL - L
4	Collection of Seagrass Shoots from Donor Sites	PA, EB, OHS	Possibility of disturbing the bottom fauna and also damaging a few healthy seagrass beds with a risk of	EB - M PA - L OHS - M

Sl. No	Applicable sub-Project Component/ Construction preparatory Work-related Sub activity (As per SF-1)	Nature of Risk (Conforming to Column 3 of SF-1)	Elaborate cause (risk) and its effect (Impact) on environment /social	Risk/Impact intensity for each type of risk/impact Low (L), Moderate (M), Substantial (S), High (H)
			equipment failure for the diver or sometimes getting hit by sting rays	
5	Manual Transplantation of sprigs/ Deployment of PVC frames tied with Seagrass shoots in the boat and deploying the frames by the divers at target sites	EB,WPH, OHS	Disturbance to the flora and fauna of the area, pieces of ropes at times causing pollution and safety risk to the diver	EB - M WPH - L OHS – M
6	Restoration Process (Monitoring and Maintenance)	OHS, WPH	Risk of diving and replacement of undergrown transplants causing turbidity in the water column and possibility of pieces of nylon ropes detached from frames causing low level of pollution	OHS – M WPH -L

Criteria for Risk Evaluation:

Low: Localized, temporary, and Negligible
Moderate: Temporary, or short-term and reversible under control
Substantial: Medium term, covering larger impact zone, partially reversible
High: Significant, non-reversible, long term, and can only be contained/ compensated

Table 9: Summary of Risk and Impacts (SF-3) for Seagrass restoration

	Environmental Risks				Social Risks						
Activity	**Land, Geology & Soil**	**General Ecology & Biodiversity**	**Waste, Pollution & Hazard**	**Protected Area (WLS, National Park etc.)**	**Land**	**Labour**	**Loss of Livelihood/ HH etc.**	**Occupational Health and safety**	**Cultural Heritage**	**Tribal**	**Gender**
Planning of Seagrass Restoration and Target Site Selection in the field	None	L	None	L	None	None	None	L	None	None	None
Fabrication of PVC Quadrats	None	None	L	None	None	L	None	None	None	None	None
Transport of PVC quadrats by barges to the site	None	None	None	None	None	L	L	L	None	None	None
Collection of Seagrass Shoots from Donor Sites	None	M	None	L	None	None	None	M	None	None	None
Manual Transplantation of sprigs/ Deployment of PVC frames tied with Seagrass shoots in the boat and deploying the frames by the divers at target sites	None	M	None	L	None	None	None	M	None	None	None
Restoration process (Monitoring and Maintena	None	None	L	None	None	None	None	M		None	None

nce)											
Overall risk is **MODERATE** due to the possibility of damage to healthy seagrass beds, and bottom fauna, and also a safety risk of divers as they remain under the water for prolonged periods of time.											

Annexure – 7 Minutes of the Public Consultation meeting

Tamil Nadu Forest Department
Wildlife Division, Ramanathapuram.

STAKEHOLDER'S MEETING MINUTES

For

Enhancing the coastal community's adaptive capacity to climate change impacts by means of protecting and restoring Kariyachalli island and the surrounding coral and sea grass habitats in Gulf of Mannar for 2024-2025 to 2027-2028

Under

Tamil Nadu Sustainably Harnessing Ocean Resources and Blue Economy Project

(TN-SHORE)

Day 1

Date: 11.06.2024
Venue: NAFCC Training Hall, Mappillaiyurani, Thoothukudi.

The chief participants of the meeting are Mr. Bakan Jagdish Sudhakar, IFS, Wildlife warden and Director, Ramanathapuram, Dr.B.R.Subramanian, World Bank consultant, Mr. K. Pusphanathan World Bank Consultant and people of coastal villages around the Kariyachalli Island from Keelavaippar in the north to Threspuram in the south.

The meeting started by around 3:00 PM and Presided by Wildlife Warden and Director, GoMBRT, Ramanathapuram. Wildlife Warden explained about the importance of corals, sea grasses and other wildlife in the sea and their role in the protection of islands as well as coastal areas since 1 island (Vilanguchalli Island) out of 4 in Tuticorin group of islands got submerged. To inculcate the importance of restoration of islands, Vaan island restoration by deploying artificial modules has been depicted by Wildlife warden.

Dr. B. R. Subramanian and Mr. K. Pusphanathan World Bank consultants, got the suggestions regarding how Vaan island restorations helps in the livelihood of fishermen in Thoothukudi.

Mr. Arul Selvam, traditional fishermen from Siluvaipatti coastal village, said that deployed .artificial modules helps in restoring coral diversity which increases the population of fish results in adequate numbers while fishermen went for fishing. Also added that GoMBRT helps in finding alternate livelihoods among the fishermen of their village.

Mr. Amalan, fishermen from Sippikulam village said that, deploying artificial modules will help in increasing the population as well as diversification of coral reefs and also helps in increasing the fish population. Also insists that fishermen should avoid fishing near the coral

reefs and it can be deliver to the people by means of creating awareness by the department peoples and added that in order to improve the livelihood of peoples depends only on sea, some funds may be arranged and given as loans to the SHG peoples and also some vocational trainings for the youths such as heavy vehicles operation, driving, etc, present in their villages and the above said points are supported by an fishermen from Pattinamaruthur village.

Mrs. Ponmalar, EDC president of Keelavaippar coastal village said that many of the youths of both genders are devoid of job opportunities as many had studied up to college level requires self employment training's such as typewriting, tailoring, aari and embroidery training for girls, basic computer training for college dropouts and also added that an meeting hall can be required for the villages to conduct meetings in the villages.

Mrs. Thamarai selvi from Keelavaippar village added that many self-help groups are doing alternate livelihoods but some sort of fund problem is there for getting loans continuously. So if additional funds are provided it will help in doing alternate jobs instead of sea dependent occupations such as fish selling, dry fish marketing etc.

Fishermen from Sippikulam village said that, about Rs.1000 to Rs. 2000 can be can be earned in a particular day if catch is more and restoration of island leads to increase in fish production helps in increased catch later. Also construction of groynes's in their village helps in controlling of the boats while handling in rough sea situations.

Consultants from World Bank added that, as many of the youths had studied in college and had bachelor degree in engineering. So training's such as OBM engine mechanical training can be helpful in earning a reasonable amount in their native place.

Wildlife warden ensures that training's such as scuba diving, lifeguard training can be helpful in employing youths in the forest department in ecotourism, patrolling, etc.

After the meeting with the stakeholders the team interacted with the self-help group in Threspuram village in Thoothukudi and knew about the eco development activities done in the fishermen villages by the GoMBRT.

Day 2

Date: 12.06.2024

Place 1: Sippikulam Village.

Dr. B. R. Subramanian and Mr. K. Pusphanathan World Bank consultants, along with the Wildlife warden and Director, Ramanathapuram, observed the Kariyachalli island from Sippikulam seashore to get some views about the island. Also, got the opinions regarding how Kariyachalli island helps in the livelihood of fishermen of Sippikulam village in Thoothukudi coast as these villages are in close proximity to the villagae.

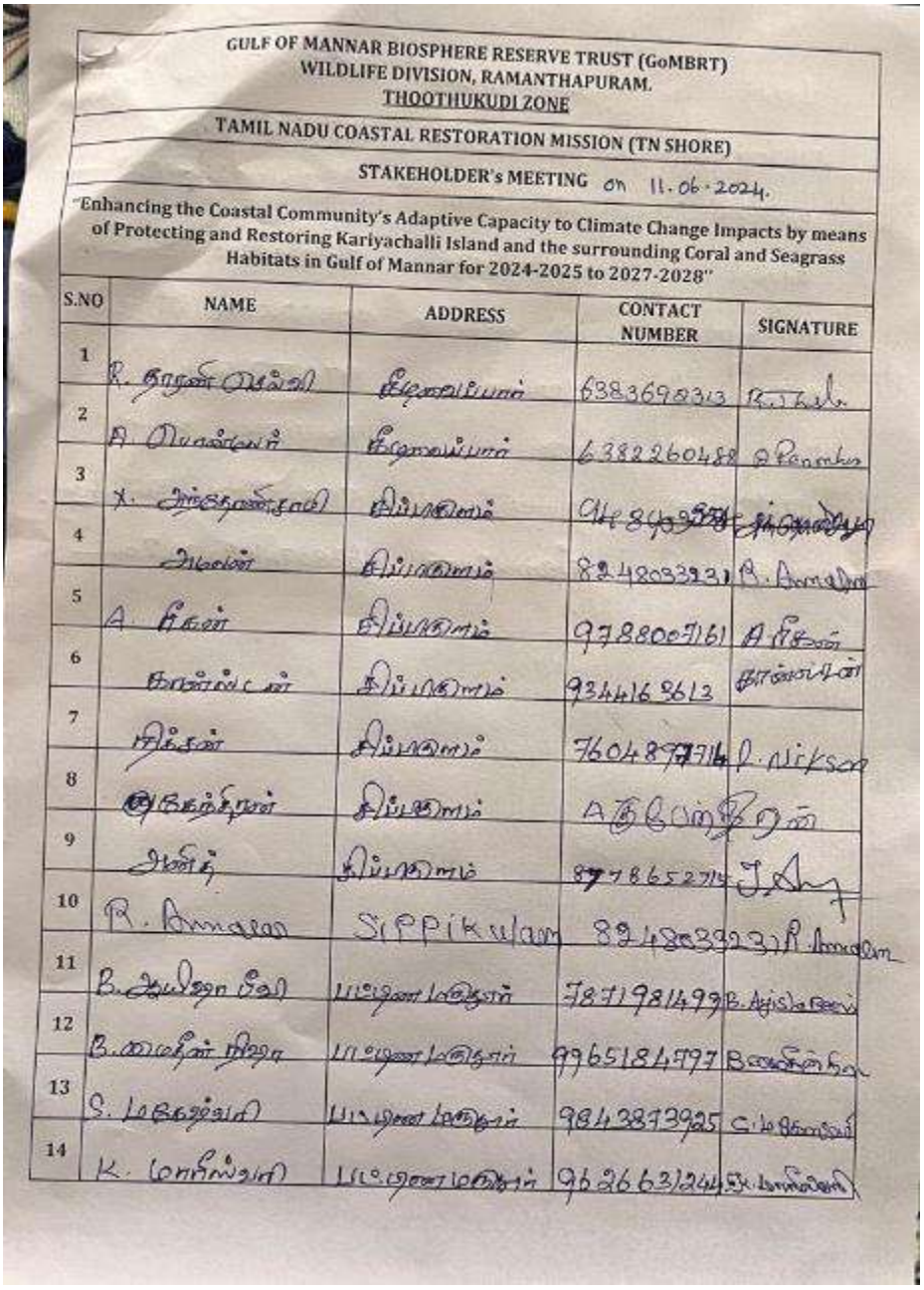
Also interacted with the women residing in the villages such as Keelavaippar and Sippikulam added that by restoring coral diversity, the fish population around Kariyachalli Island keeps on increasing and their activities pertaining to eco development from their side. Also they added that trainings like aari and embroidery work, tailoring, palmyrah craft making, etc,may be useful for the youths residing in their villages.

Place 2: Tharuvaikulam Village.

The team interacted with the fishermen and fisherwomen of Tharuvaikulam village and got information about how fishing occupation is happening in their village and also enquired about the types of boats used for fishing. Mr. Antony Lawrence of Tharuvaikulam village said that fibre boats, vallam, mechanized boats are used for fishing and also added that restoration of vaan island helps in the stability of the island and also helps directly in increased fish population. Also added that corals which are depleted by coral mining had been stopped and protection measures were taken for regenerating it. Women in the village added that they requires self-employment training's such as typewriting, tailoring, aari and embroidery training will be helpful for girls and youths in the villages.

Place 3: Vellapatti Village.

Mr. Savarianantham of Vellapatti village said that most of the peoples in the villages used to go for fishing by vallam and fibre boats and also said that restoration of Vaan Island helps in increased fish population due to the growth of coral reefs around the artificial concrete structure. Women in the village added that they requires self-employment training's such as tailoring, aari and embroidery training will be helpful for girls and also trainings such as heavy vehicle operation training, motorcycle mechanic training for youths in the villages. SHG formed by the women in the village engaged in making of fish pickle, prawn pickles, fish sambal, dry fish powder etc., being prepared and these activities are explained to them.



GULF OF MANNAR BIOSPHERE RESERVE TRUST (GoMBRT)
WILDLIFE DIVISION, RAMANTHAPURAM,
THOOTHUKUDI ZONE

TAMIL NADU COASTAL RESTORATION MISSION (TN SHORE)

STAKEHOLDER's MEETING on 11.06.2024.

"Enhancing the Coastal Community's Adaptive Capacity to Climate Change Impacts by means of Protecting and Restoring Kariyachalli Island and the surrounding Coral and Seagrass Habitats in Gulf of Mannar for 2024-2025 to 2027-2028"

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2	A. [illegible]	[illegible]	6382260488	
3	[illegible]	[illegible]	[illegible]	
4	[illegible]	[illegible]	8248033931	
5	A [illegible]	[illegible]	9788007161	
6	[illegible]	[illegible]	9344168613	
7	[illegible]	[illegible]	7604877714	
8	[illegible]	[illegible]	[illegible]	
9	[illegible]	[illegible]	8778652714	
10	R. [illegible]	SIPPIKULAM	8248033931	
11	B. [illegible]	[illegible]	7871981499	
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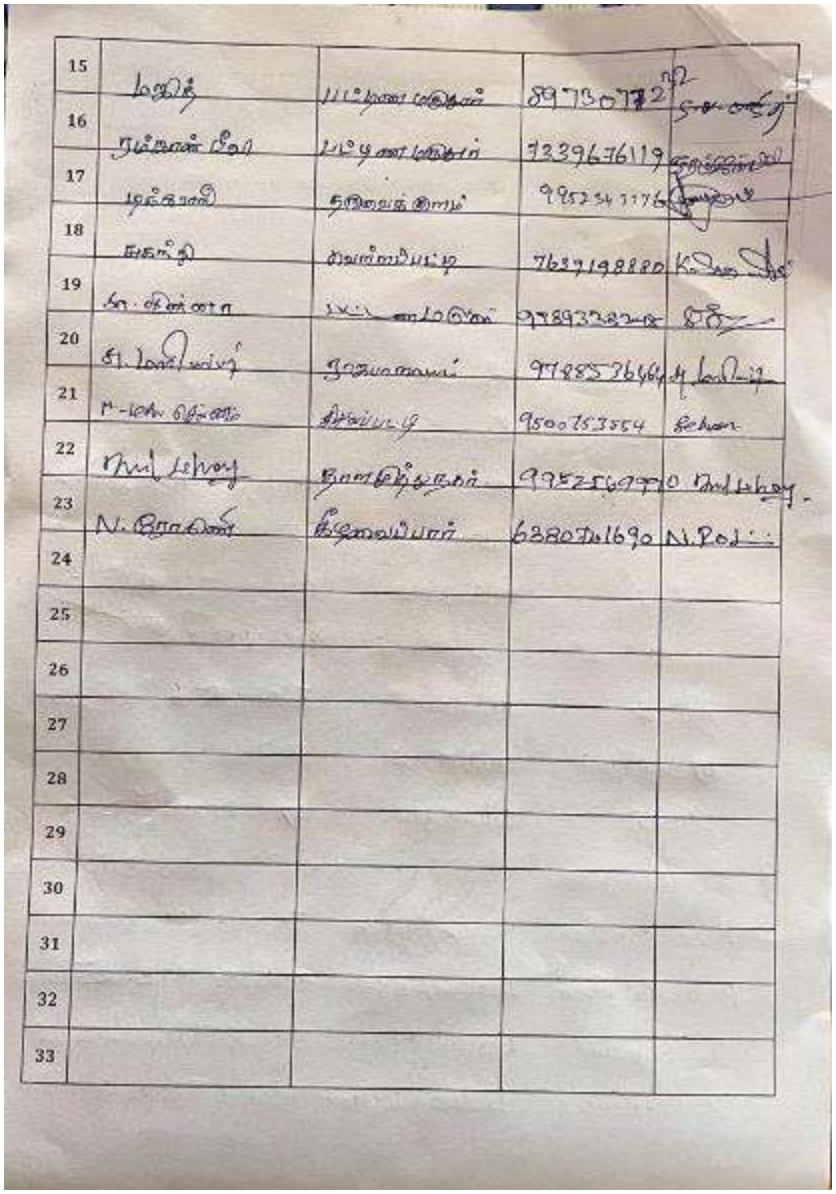
13	S. [illegible]	[illegible]	9843873925	
14	K. [illegible]	[illegible]	9626631244	



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Annexure 8: Administration chart