പതിനാറാം കേരളനിയമസഭ

രണ്ടാം സമ്മേളനം

നക്ഷത്രചിഹ്നമിടാത്ത ചോദ്യം നമ്പർ: 1041 **14-10-2026-ൽ മറുപടിയ്ക്ക്**

അജാന്തൂർ മത്സ്യബന്ധന തുറമുഖം

ചോദ്യം ഉന്നയിച്ച അംഗങ്ങൾ **മറുപടി നൽകിയ മന്ത്രി**

ശ്രീ. ഗോവിന്ദൻ പള്ളിക്കാപ്പിൽ ശ്രീ. വി. ഇ. അബ്ദുൽ ഗഫൂർ
(മത്സ്യബന്ധനം - സാമൂഹ്യനീതി വകുപ്പ് മന്ത്രി)

(എ) അജാന്തൂർ മത്സ്യബന്ധന തുറമുഖം സ്ഥാപിക്കുന്നതിനുള്ള നടപടികൾ സ്വീകരിച്ചിട്ടുണ്ടോയെന്ന് വ്യക്തമാക്കാമോ; ഉണ്ടെങ്കിൽ എന്തൊക്കെ നടപടികളാണ് സ്വീകരിച്ചതെന്ന് വിശദമാക്കാമോ;

മറുപടി: അജാന്തൂർ മത്സ്യബന്ധന തുറമുഖത്തിന്റെ നിർമ്മാണത്തിന് മുന്നോടിയായിട്ടുള്ള ഇൻവെസ്റ്റിഗേഷൻ സ്റ്റഡി, മോഡൽ സ്റ്റഡി, flume സ്റ്റഡി, CRZ മാപ്പിംഗ്, എൻവയോൺമെന്റൽ ഇംപാക്ട് അസസ്മെന്റ് (EIA) സ്റ്റഡി എന്നിവ പൂർത്തീകരിച്ചിട്ടുണ്ട്. കൂടാതെ, CRZ ക്ലിയറൻസ് ലഭ്യമാക്കുന്നതിനായി ആവശ്യമായ എല്ലാ രേഖകളും സഹിതമുള്ള അപേക്ഷ ഹാർബർ എഞ്ചിനീയറിംഗ് വകുപ്പ് മുഖേന കേരള കോസ്റ്റൽ സോൺ മാനേജ്മെന്റ് അതോറിറ്റി (KCZMA)— ക്ക് സമർപ്പിച്ചിട്ടുണ്ട്.

നിർദിഷ്ട തുറമുഖ നിർമ്മാണത്തിനായുള്ള 101.33 കോടി രൂപയുടെ വിശദമായ പദ്ധതി രൂപരേഖ PMMSY സ്കീമിൽ ഉൾപ്പെടുത്തി അംഗികാരം ലഭ്യമാക്കുന്നതിനായി ഹാർബർ എഞ്ചിനീയറിംഗ് വകുപ്പ് സമർപ്പിച്ചിരുന്നു. ആയത് State level Approval and Monitoring Committee (SLAMC) അംഗീകാരത്തോടെ കേന്ദ്ര സർക്കാരിൽ സമർപ്പിക്കുകയും തുടർന്ന് 27/03/2022 തീയതിയിൽ നടന്ന കേന്ദ്ര സർക്കാരിന്റെ പ്രോജക്ട് അപ്രൈസൽ കമ്മിറ്റിയിൽ മേൽ പദ്ധതി പരിഗണിക്കുകയും ഭാവി വികസനം കൂടി കണക്കിലെടുത്ത് ബേസിൻ ഏരിയ വലുതാക്കി പദ്ധതി രൂപരേഖ പുതുക്കി സമർപ്പിക്കുന്നതിന് നിർദ്ദേശിക്കുകയും ചെയ്തു.

കമ്മിറ്റിയുടെ നിർദ്ദേശം അനുസരിച്ച് വീണ്ടും പൂർണ്ണ തോതിലുള്ള ഒരു മാതൃകാ പഠനം CWPRS മുഖേന നടത്തി അന്തിമ റിപ്പോർട്ട് ലഭിച്ചതിന്റെ അടിസ്ഥാനത്തിൽ 200 കോടി രൂപയുടെ പുതുക്കിയ പദ്ധതി രൂപരേഖ 15/01/2025-ൽ നടന്ന സ്റ്റേറ്റ് ലെവൽ അപ്രൂവൽ ആന്റ് മോണിറ്ററിംഗ് കമ്മിറ്റി അംഗീകരിക്കുകയും തുടർന്ന് കേന്ദ്ര സർക്കാർ അനുമതിക്കായി സമർപ്പിക്കുകയും ചെയ്തിരുന്നു. സെൻട്രൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് കോസ്റ്റൽ എഞ്ചിനീയറിംഗ്

ഫോർ ഫിഷറി (CICEF) നടത്തിയ ടെക്നിക്കൽ സ്റ്റഡിനി പ്രകാരം അജാന്തൂർ ഫിഷിംഗ് ഹാർബർ പദ്ധതി ഇക്കണോമിക്കലി വയബിൾ അല്ല എന്ന് കേന്ദ്രസർക്കാർ അറിയിക്കുകയുണ്ടായി. തുടർന്ന് അജാന്തൂർ ഫിഷിംഗ് ഹാർബറിന്റെ ഒന്നാം ഘട്ട വികസനത്തിനായി 150.00 കോടി രൂപയുടെ

വിശദമായ പദ്ധതി രൂപരേഖ FIDF പദ്ധതിയിൽ ഉൾപ്പെടുത്തി അംഗീകാരം ലഭ്യമാക്കുന്നതിനായി ഹാർബർ എഞ്ചിനീയറിംഗ് വകുപ്പ് സമർപ്പിച്ച പ്രൊപ്പോസൽ പരിശോധിച്ചുവരുന്നു.

(ബി) ഇതുമായി ബന്ധപ്പെട്ട് നാളിതുവരെ നടത്തിയ പഠന റിപ്പോർട്ടിന്റെ പകർപ്പുകളും വിശദാംശങ്ങളും ലഭ്യമാക്കാമോ;

<u>മറുപടി:</u> ലഭ്യമാക്കാം; ഇതുമായി ബന്ധപ്പെട്ട് വിവിധ ഏജൻസികൾ നടത്തിയ പഠനങ്ങൾ ചുവടെ ചേർക്കുന്നു.

1. Mathematical Model Studies for Littoral Drift & shoreline evolution due to the proposed Fishery Harbour at Ajanur - Technical Report No.5357/February 2016.

2. Wave propagation Studies to determine Wave climate for the development for Fish Landing Facilities at Ajanur - Technical Report No.5436 /November 2016.

3. Desk and Wave Flume Studies for the design of breakwater for Fishery Harbour at Ajanur in Kasargod District, Kerala.

4. Mathematical Model Studies to assess hydro dynamics and siltation due to construction of Fishing Harbour at Ajanur at Kerala.

5. Environmental impact assessment report for proposed construction of Ajanur Fishing Harbour.

6. Risk assessment and disaster management plan for proposed construction of Ajanur Fishing Harbour.

7. Additional mathematical model studies for wave Tranquility for revised layout of Fisheries Harbour at Ajanur, Kerala – July 2022.

8. CRZ status report 2025.

വിശാദംശങ്ങൾ അനുബന്ധം ആയി ചേർക്കുന്നു.

(സി) പദ്ധതി യാഥാർഥ്യമാക്കുന്നതിലേക്കായി സ്വീകരിച്ച നടപടികൾ സംബന്ധിച്ച് വിശദാംശങ്ങൾ ലഭ്യമാക്കാമോ?

<u>മറുപടി:</u> (i) അജാനൂർ മത്സ്യബന്ധന തുറമുഖത്തിന്റെ നിർമ്മാണത്തിനായുള്ള അന്വേഷണ ഗവേഷണ പ്രവർത്തനങ്ങൾക്കായി സർക്കാർ ഉത്തരവ് നമ്പർ G.O(Rt)NO.58/12/F&PD തിയതി 18/01/2012 പ്രകാരം 24 ലക്ഷം രൂപയ്ക്ക് ഭരണാനുമതി നൽകി.

ii) സർക്കാർ ഉത്തരവ് നമ്പർ G.O(Rt)NO.260/13/F&PD തിയതി 30/03/2013 പ്രകാരം 53 ലക്ഷം രൂപയ്ക്ക് പുതുക്കിയ ഭരണാനുമതി നൽകി.

iii) നിർദ്ദിഷ്ട തുറമുഖത്തിന്റെ നിർമ്മാണത്തിന് മുന്നോടിയായിട്ടുള്ള ഇൻവെസ്റ്റിഗേഷൻ സ്റ്റഡി, മോഡൽ സ്റ്റഡി, flume സ്റ്റഡി, CRZ മാപ്പിംഗ്, എൻവയോൺമെന്റൽ ഇമ്പാക്ട് അസസ്മെന്റ് (EIA) സ്റ്റഡി എന്നിവ പൂർത്തികരിച്ചിട്ടുണ്ട്. പരിസ്ഥിതി ആഘാത പഠന റിപ്പോർട്ട് M/s. Ultratech Pvt. Ltd-ൽ നിന്നും സെപ്റ്റംബർ 2025-ന് ലഭ്യമായിട്ടുണ്ട്. കൂടാതെ, CRZ ക്ലിയറൻസ് ലഭ്യമാക്കുന്നതിനായി ആവശ്യമായ എല്ലാ രേഖകളും സഹിതമുള്ള അപേക്ഷ ഹാർബർ എഞ്ചിനീയറിംഗ് വകുപ്പ് മുഖേന കേരള കോസ്റ്റൽ സോൺ മാനേജ്മെന്റ് അതോറിറ്റി (KCZMA) - ക്ക് സമർപ്പിച്ചിട്ടുണ്ട്.

iv) അജാന്നൂരിൽ ഫിഷിംഗ് ഹാർബർ നിർമിക്കുന്നതിനു വേണ്ടിയുള്ള മാതൃകാ പഠനം നടത്താൻ CWPRS പുനെ-യെ ചുമതലപ്പെടുത്തുകയും 2016-ൽ മാതൃകാ പഠന റിപ്പോർട്ടുകൾ ലഭ്യമാക്കുകയും ചെയ്തിട്ടുണ്ട്.

v) അജാന്നൂർ ഫിഷിംഗ് ഹാർബർ നിർമ്മിക്കുമ്പോൾ ഷോർ ലൈൻ മാറ്റങ്ങൾ, ചിത്താരിപ്പുഴയുടെ ഗതിമാറ്റം എന്നിവ കൂടി കണക്കിലെടുത്ത് ആവശ്യമായ river training work കൂടി ഉൾപ്പെടുത്തിയുള്ള പുതുക്കിയ പഠന റിപ്പോർട്ടിന്റെ അടിസ്ഥാനത്തിൽ പ്രസ്തുത തുറമുഖ നിർമ്മാണത്തിനായുള്ള 101.33 കോടി രൂപയുടെ വിശദമായ പദ്ധതി രൂപരേഖ എന്നിവ തയ്യാറാക്കി PMMSY സ്കീമിൽ ഉൾപ്പെടുത്തി അംഗീകാരം ലഭ്യമാക്കുന്നതിനായി സർക്കാരിൽ ലഭ്യമായി

vi) 24/03/2022 നടന്ന State level Approval and Monitoring Committee (SLAMC) മീറ്റിംഗിൽ പ്രസ്തുത പദ്ധതി രൂപരേഖ അംഗീകരിക്കുകയും ആയതു കേന്ദ്ര സർക്കാരിന് അംഗീകാരത്തിനായി സമർപ്പിക്കുകയും ചെയ്തു. തുടർന്ന് 27/03/2022 തീയതിയിൽ നടന്ന കേന്ദ്ര സർക്കാരിന്റെ പ്രോജക്ട് അപ്രൈസൽ കമ്മിറ്റിയിൽ മേൽ പദ്ധതി പരിഗണിക്കുകയും ഭാവി വികസനം കൂടി കണക്കിലെടുത്ത് ബേസിൻ ഏരിയ വലുതാക്കി പദ്ധതി രൂപരേഖ പുതുക്കി സമർപ്പിക്കുന്നതിന് നിർദ്ദേശിക്കുകയും ചെയ്തു.

കമ്മിറ്റിയുടെ നിർദ്ദേശം അനുസരിച്ച് വീണ്ടും പൂർണ്ണ തോതിലുള്ള ഒരു മാതൃകാ പഠനം CWPRS മുഖേന നടത്തി അന്തിമ റിപ്പോർട്ട് ലഭിച്ചതിന്റെ അടിസ്ഥാനത്തിൽ 200 കോടി രൂപയുടെ പുതുക്കിയ പദ്ധതി രൂപരേഖ 15/01/2025 - ൽ നടന്ന സ്റ്റേറ്റ് ലെവൽ അപ്രൂവൽ ആന്റ് മോണിറ്ററിംഗ് കമ്മിറ്റി (SLAMC) അംഗീകരിക്കുകയും തുടർന്ന് കേന്ദ്ര സർക്കാർ അനുമതിക്കായി 24/01/2025 - ൽ സമർപ്പിക്കുകയും ചെയ്തിരുന്നു.

vii) സെൻട്രൽ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് കോസ്റ്റൽ എഞ്ചിനീയറിംഗ് ഫോർ ഫിഷറി (CICEF) നടത്തിയ ടെക്നിക്കൽ സ്ക്രൂട്ടിനി പ്രകാരം അജാന്നൂർ ഫിഷിംഗ് ഹാർബർ പദ്ധതി ഇക്കണോമിക്കലി വയബിൾ അല്ല എന്ന് കേന്ദ്രസർക്കാർ അറിയിച്ചതിനെ തുടർന്ന് ആയതിൻ്റെ പ്രായോഗികതയും ആവശ്യകതയും വിശദീകരിച്ച്, അജാന്നൂർ ഫിഷിംഗ് ഹാർബറിന്റെ ഒന്നാം വികസനത്തിനായി 150.00 കോടി രൂപയുടെ വിശദമായ പദ്ധതി രൂപരേഖ FIDF പദ്ധതിയിൽ ഉൾപെടുത്തുന്നതിനായി ഹാർബർ എഞ്ചിനീയറിംഗ് വകുപ്പ് സമർപ്പിച്ച പ്രൊപ്പോസൽ പരിശോധിച്ചുവരുന്നു .

സെക്ഷൻ ഓഫീസർ

MATHEMATICAL MODEL STUDIES FOR LITTORAL DRIFT AND SHORELINE CHANGES DUE TO THE PROPOSED FISHERY HARBOUR AT AJANUR, DIST. KASARGOD, KERALA

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1. INTRODUCTION

Ajanur is one of the prominent fishing villages of Kasargod district with extensive fishing activity. The fishermen of this locality also used to carry out mechanized fishing in smaller scale. In order to meet the temporary needs of the fishermen of the area, a fish landing centre was constructed as part of ICAD project. Further, it is reported that there is a demand from the fishermen of nearby area of Chithari Kadapuram to construct a fish landing centre for them. All these indicate that the extensive fishing operation used to take place in these regions.

In preliminary studies, it is reported that the establishment of a fishery harbour at Ajanur would not only be essential for the development of the region but also beneficial to all the sections of fishermen communities and the fishery industry as a whole in the region resulting in major contributions to the economic development of the region. In view of this, mathematical model studies have been referred to CWPRS to access littoral drift distribution and changes in shoreline at the proposed location of the Ajanur fishing harbour.

The project site is situated near the estuary of Chithari backwaters in Kasargod taluka. The site is easily accessible from major roads through a network of coastal roads. The site is located about 18.0 km north-west of Cheruvatur fishery harbour and about 26.0 km south-east of Kasargod fishing harbour as shown in Fig.1.

2. SCOPE OF STUDIES

The scope of the work includes mathematical model studies for the

(i) Estimation of seasonal and annual littoral drift rates and their cross-shore distributions, and

(ii) Assessment of shoreline changes due to the proposed fishing harbour at Ajanur using LITPACK software.

3. PROPOSALS OF HARBOUR LAYOUT

Project Authorities have suggested three different layouts for the proposed fishing harbour at Ajanur. Brief description about these proposals is given as under. The breakwaters in all the three proposals are extended upto 4 m to 4.4 m depth.

Proposal 1: Layout 1 consists of a north breakwater of length 335 m. The southern breakwater is of total length as 610 m consisting of normal to the shore of length 270 m and further extended along the shore of length 340 m (Fig.2A).

Proposal 2: In Layout 2, the northern breakwater consists of shore normal length of 250 m further extended along the shore of length 315 m. The southern breakwater is of length 385 m (Fig.2B).

Proposal 3: In Layout 3, the northern breakwater of total length of 960 m consists of shore normal length of 260 m and along shore length of 700 m. The southern breakwater is of length 295 m (Fig.2C).

4. SITE CONDITIONS

4.1 Offshore wave climate

For simulation of littoral drift and shoreline changes, nearshore wave data is essential. Instrumentally observed wave data near the study area over a period of several years, if available, is the best suited for this purpose. However, if such data are not available, the nearshore wave climate can be obtained usually by transforming the offshore wave data to a nearshore location near the study area with the help of mathematical modeling technique. Due to unavailability of near shore wave data, generally the wave data observed by the ships plying in offshore region of Ajanur reported by India Meteorological Department (IMD) during the past 30 years were considered to arrive at nearshore wave data. The frequency distribution analysis of the offshore wave data for seasonal and annual periods was carried out as presented in Tables 1(A)-1(D). The corresponding wave rose diagrams are shown in Figs.3(A)-3(D).

From Table 1(A) and Fig.3(A), it could be seen that in the offshore region, the waves approach predominantly from SW and NW directions during south-west monsoon with the maximum wave height of the order of 4.5 m. During north-east monsoon period [Table 1(B) and Fig.3(B)], waves approach predominantly from NW and NE directions with the maximum wave height of the order of 3.0 m. In non-monsoon period [Table 1(C) and Fig.3(C)], the predominant directions of waves are WSW to North directions with the maximum wave height of the order of 3.0 m. The wave climate during the entire year [Table 1(D) and Fig.3(D)] indicates that the predominant wave directions in deep water are SW to NNE with the maximum wave height of the order of 4.5 m.

In order to get the nearshore wave climate, the deep water wave data were transformed at a location of -10 m depth contour near the site of the proposed fishery harbour of Ajanur using SW module of MIKE 21 software.

4.2 Tidal Levels and Currents

The proposed site of development is about 25 km south of Kasargod. Important tidal levels at Kasargod with respect to Chart Datum (as per Admiralty chart No.217 & 2029) are reported to be as under:

MHHW	:	1.4 m
MLHW	:	1.3 m
MSL	:	1.0 m
MHLW	:	0.9 m
MLLW	:	0.4 m

This indicates that the maximum tidal range at the study area is of the order of 1.0 m. Tidal currents are generally parallel to the coastline and directed northward during flood as well as ebb tide with the maximum magnitude of the order of 0.4 m/s.

4.3 Sediment Characteristics

Bed samples were collected from different locations at the proposed site at Ajanur (Fig.4). Based on the analyses of the bed samples, the bed material in the vicinity of the proposed site is mainly composed of medium to fine sand and silt, whose mean grain size, D_{50} varies from 0.05 mm to 0.6 mm.

4.4 Littoral Drift

Longshore sediment transport rates for Manjeshwar (Kerala) coastal regions are estimated and reported in CWPRS Technical Report No.4684. It is reported that the littoral drift having annual net transport of 0.3 million m^3 (southward) and the gross transport of 0.7 million m^3 occurs near Manjeshwar coastal region, which is about 50 km north of Ajanur. Several other literatures (Sajeev et al., 1997 and Sanilkumar et al., 2006) are available in which longshore sediment transport rate of nearby locations is mentioned. They estimated the annual net transport of 0.11 million cum (southward) and the gross transport of 0.26 million m^3 at Kozhikode, which is about 150 km south of Ajanur. Chandramohan et al. (1990) computed longshore transport along south Indian coast using Energy Flux Method (Shore Protection Manual, 1984). At Cochin, they predicted southward and northward longshore transport of 0.98 and 0.69 million m^3 respectively. Furthermore, it is mentioned here that the Energy Flux Method, in general, gives higher values of longshore transport

5. MODELLING TECHNIQUES

For these studies, mathematical models; MIKE 21 SW and LITPACK, were used for the simulation of nearshore wave field & wave disturbance near the location of the proposed fishery harbour at Ajanur. The MIKE 21 SW and LITPACK are the widely used commercial

software developed by Danish Hydraulics Institute (DHI), Denmark. Brief description of these models is given below:

5.1 MIKE 21 SW Model

For computation of wave transformation from deep water to nearshore region, MIKE 21 Spectral Wave (SW) model was used. The model is capable of simulating the growth, decay and transformation of wind generated waves and swells in both offshore and coastal areas. MIKE 21 SW is a new generation spectral wind-wave model based on unstructured meshes, which takes into account all the important phenomena like wave growth by influence of wind, non-linear wave-wave interaction, dissipations due to white-capping, bottom friction and depth-induced breaking. It can also model diffraction effects due to the presence of large structures which becomes increasingly important in the presence of coastal structures like breakwaters, groins etc. The effect of refraction and shoaling of waves due to depth variations and wave-current interaction are also considered in the model. The outputs of the model are the regular wave parameters which include the significant wave height, mean wave period, mean wave direction directional standard deviation and the wave radiation stresses. The governing equation used in the model is the wave action balance equation. The equation is solved using cell centred finite volume method. In horizontal Cartesian co-ordinates the conservation equation for wave action is

$$\frac{\partial N}{\partial t} + \nabla.(\vec{\nu} N) = \frac{S}{\sigma}$$

Where

$N(\vec{x}, \sigma, \theta, t)$	= the action density,
t	= time (sec),
$\vec{x}$ (x,y)	= Cartesian co- ordinates,
$\vec{\nu}$ (C_x, C_y, C_σ, C_θ)	= propagation velocity of a wave group in four dimensional phase space $\vec{x}$, σ and θ
S	= source term for the energy balance equation.
∇	= the four dimensional differential operator in $\vec{x}$, σ and θ.

5.2 LITPACK Software

In order to simulate littoral drift & its distribution, shoreline changes etc., LITPACK software was used. In LITPACK model, the cross-shore distribution of longshore current, wave height and setup for an arbitrary beach profile are computed by solving the longshore and cross-shore

momentum balance equations. The longshore current model includes effect of regular and irregular waves, influence of tidal currents, wind stress and non-uniform bottom friction, wave refraction, shoaling and breaking.

Calculation of longshore sediment transport is based on the local wave, current and sediment characteristics. The sediment transport model is an intra-wave period model, which takes into account time-varying distribution of both suspended load and bed load within the wave period in combined wave and current motion including the effect of wave breaking. The model gives cross-shore distribution of longshore sediment transport for an arbitrary, non-uniform bathymetry and sediment profile. The annual sediment budget is calculated based on the contribution of transport from each of the wave incidents occurring during the year. Thus the total annual drift is the sum of the contribution of transport from all incident waves.

Coastline evolution analyses are performed with the LITLINE module of LITPACK modelling system. LITLINE simulates the coastal response to gradients in the longshore sediment transport capacity resulting from natural features and a wide variety of coastal structures. LITLINE calculates the coastline evolution by solving a continuity equation for the sediment in the littoral zone. The influence of structures, sources and sinks are also included. The basic input data for running the model are the longshore relative coastline alignment, cross-shore profile description and bathymetry, active depth of transport and depth contour angles at each grid point, environmental data with wave properties, tidal currents and water levels position and size of structures etc.

6. WAVE TRANSFORMATION FROM DEEP SEA TO NEARSHORE LOCATION

Bathymetry in the offshore region of Ajanur is fairly simple, consists of almost parallel contours from -10 m depth upto -60 m depth. The bathymetric data in the offshore were taken from CMAP database. It could be seen from Fig.4 that the bed slope in the vicinity of the proposed fishery harbour is very mild (1:500). An area of 75 km alongshore and 20 km cross-shore with an unstructured mesh was considered for the simulation of MIKE 21 SW model. In the cross-shore, it extends from high water line near the shore to -60 m depth contour in deep sea. The model was run for incident waves of wave height 5.0 m for all the predominant wave directions in deep sea viz. SE, SSE, South, SSW, SW, WSW, West, WNW, NW, NNW and North.

Wave heights and wave directions, at -10 m depth contour near the location of the proposed fishery harbour were extracted from the model results for all the incident wave directions. The extracted information of wave heights and directions at -10 m depth contour was applied to

seasonal and yearly offshore wave climate to obtain frequency distribution of wave heights and wave directions near the location of the proposed fishery harbour at Ajanur.

6.1 Transformation Table

Wave climate at the offshore zone was transformed to a nearshore location called as Refraction Point (Fig.5) at -10 m depth contour near the proposed fishery harbour site at Ajanur. The MIKE 21 SW model was simulated for a significant wave height (Hs) of 5 m and a significant wave period (Ts) of 10 sec occurring at offshore boundaries. The transformation table was applied to the deep water wave data [Table 1(A) - 1(D)] to obtain the frequency distribution of waves at the nearshore Refraction Point (at –10 m depth contour) for SW monsoon, NE monsoon, non-monsoon and annual periods. The nearshore wave climate obtained for SW monsoon, NE monsoon, Non-monsoon and Annual periods are shown in Tables 2(A)-2(D), which indicate the frequency distribution of the wave heights and directions. The corresponding wave rose diagrams are shown in Figs.6(A)-5(D).

The transformation table obtained from deep water to the Refraction Point at -10 m depth contour using MIKE 21 SW model for wave propagation is given below:

WAVE TRANSFORMATION FROM DEEP TO SHALLOW WATER AT –10 m DEPTH CONTOUR NEAR THE PROPOSED HARBOUR AT AJANUR

Wave Direction(^{0} N)		Ratio of inshore wave height to offshore wave height (Hi/Ho)
offshore	Inshore	
0	301.4	0.187
22.5	303	0
45	303	0
67.5	0	0
90	0	0
112.5	209.2	0
135	209	0.206
157.5	211.2	0.373
180	215.7	0.543
202.5	223.6	0.666
225	235.6	0.73
247.5	249.8	0.746
270	264.4	0.723
292.5	278.4	0.643
315	289.6	0.506
337.5	297	0.34
360	301.4	0.187

6.2 Nearshore Wave Climate

From Table 2(A) and Fig.6(A) it could be observed that in the nearshore region, the waves having the maximum wave height of the order of 3.5 m approach predominantly from West, WSW and SW directions with percentage of occurrence 59%, 15% and 13% respectively during south-west monsoon. During the NE monsoon period [Table 2(B) and Fig.6(B)], waves having the maximum wave height of the order of 3.0 m approach predominantly from West, WNW, WSW and SW directions with the percentage of occurrence of 11%, 22%, 7% and 13% respectively. In the non-monsoon period [Table 2(C) and Fig.6(C)], the predominant directions of waves having maximum wave height of the order of 3.0 m are from WNW and West predominant directions with percentage occurrence of 37% and 12% respectively. The wave climate during the entire year [Table 2(D) and Fig. 6(D)] indicates that the predominant wave directions are from WNW, West and SW with the maximum wave height of the order of 3.5 m and the percentage occurrence of 21%, 26% and 12% respectively for the annual period.

7. SIMULATION OF LITTORAL DRIFT AND SHORELINE CHANGES

LITPACK model is used to estimate seasonal/ annual littoral drift rates and its distribution on the profile normal to the shoreline. The model assumes the depth contours parallel to the seashore. Fig.7 shows the beach profile (cross-shore bed profile) near the location of the proposed harbour at Cochin which is used for the littoral drift computation. Profile covers a distance of 3.5 km extending upto about -10 m depth contour. It could be seen from the figure that -5 m depth contour is about 1.0 km from the coastline. Profile is discretised into 350 grid points with uniform grid size of 10 m. Littoral drift at the proposed site of Ajanur was simulated using LITDRIFT module of LITPACK, which takes into account the cross-shore profile, the sediment characteristics and the wave climate as input.

7.1 Littoral Drift

The general orientation of the coastline at the proposed site is NW-SE making an angle of about 335^0 with respect to north. Further, depending on the wave direction with respect to the coastline, the littoral drift will be either directed northward or southward along the shoreline. The model was simulated for the cross-shore profiles for the seasonal and the annual wave climates as mentioned in Tables 2(A)-2(D).

Based on the simulation of littoral drift, the annual net and the gross transports were estimated to be of the order of 0.413 and 0.649 million m^3 respectively. The model was also used to compute seasonal transport rates. The distribution of littoral transport rates for the three seasons and for the annual period as shown in Figs.8(A)-8(D). It may be noted that the northward drift is indicated as negative and the southward drift is indicated as positive in the

figures. From Fig.8(A) it could be seen that during SW monsoon, southward transport is more than the northward transport and the transport occurs within a range of 500 m from the shoreline. It could also be seen that main drift moves within a range of 200 m from coastline. From Fig.8(B) it could be seen that during NE monsoon, northward transport is more than southward transport and the transport is mainly confined to a range of 150 m from the shoreline. During non-monsoon period, the southward transport equals the northward transport and the major transport occurs within a range of 150 m from the shoreline as shown in Fig.8(C). The distribution of annual transport, shown in Fig.8(D), indicates that the sediment drift moves within a range of 500 m from the shoreline as the cross-shore profile has steep slope. Further, it could be seen that the southward transport is significantly more than the northward transport during SW monsoon season. It could also be seen that the peak transport occurs at about 50 m from the shoreline and about 75% transport occurs between 50 m to 150 m from shoreline i.e. between +0.0 to –3.5 m depth contours.

Annual and seasonal net and gross littoral drift were estimated using LITDRIFT model. The northward and the southward drift are calculated based on the gross and the net littoral drift. The littoral drifts are reported in the following table:

TRANSPORT RATES (million cum)

Period	Northward	Southward	Net	Gross
SW monsoon	0.0795	0.511	-0.431	0.590
NE monsoon	0.021	0.016	0.0057	0.037
Non-monsoon	0.025	0.025	0.0	0.05
Annual	0.118	0.531	-0.413	0.649

It could be seen from the table that the annual northward and southward drift are 0.118 million cum and 0.531 million cum respectively while the net and the gross transports are 0.413 million cum and 0.649 million cum respectively. The net transport is towards south. It is also observed that the major southward transport occurs during SW monsoon.

7.2 SHORELINE EVOLUTION

For the shoreline evolution model, a shoreline of 8.0 km length was considered. The length was divided into 800 grid points with uniform grid size of 10 m. The proposed location of the Ajanur fishing harbour was schematically located in the middle of the coastline. Projection of the breakwater was taken for the computation of shoreline evolution. It was seen that the projection adopted was found to be appropriate for all the three proposals (Figs.2A-2C) given by the Project Authorities. The transport rates were computed for the above mentioned profile,

which was used as input to the shoreline evolution model for LITLINE module of LITPACK software.

In order to calibrate the model, the existing profile along with shoreline was considered. The model was simulated for SW monsoon period and it was found that the model results match well with the figure seen in Google earth map. Field observed shoreline data collected near the proposed location of fishery harbour during the different months of the year 2013 (May, July-September) and 2014-15 (July 2014 to February 2015) was provided by the project authority. During the given period in the year 2013, it was observed that the maximum deposition of the order of 0.2 m in the south of the gut and the erosion of about 0.03 m in the north of the gut had occurred. Further, in the year 2014, similar trend was observed, however, the magnitude of the deposition and the erosion were marginally less. Based on these data, it can be concluded that a net littoral drift of mild magnitude in north direction exists in the study area. The phenomena of deposition and erosion could be observed at the study area due to the presence of shoals near the gut.

The calibrated model was used to simulate for the proposed condition in which layout of the proposed fishing harbour was incorporated in the model. The model was run with the schematic layout for a period of 10 years. The predicted shoreline change obtained from the model simulation is shown in Fig.9. As the net transport is directed towards south, the deposition on the north side of the extended groyne is noticed while on the southern side erosion is observed.

Further, model was simulated subsequently for a period of 2, 4, 6, 8 and 10 years and the maximum cross-shore advancement for each period would be obtained as 34 m, 44 m, 52 m, 60 m and 68 m respectively from the prevailing coastline position on the northern side of the proposed north breakwater. It may be noted that during the LITPACK model simulation, it has been assumed that the shoreline consisted of erodible material. Further, the corresponding longshore effect of deposition was felt for a length of about 2500 m. The maximum cross-shore erosion of the shoreline in 10 years period would be of the order of 40 m south of the southern breakwater with longshore effect would occur upto about 1500 m from the proposed position of the southern breakwater.

The model results presented herein are based on the simulation with considering the effect of the River Chithari draining in the north of the proposed location of the fishing harbour. It was assumed that the quantity of water and sediment discharged from the river was extremely low and their effect on the littoral drift and on the shoreline is insignificant.

8. CONCLUSIONS

Mathematical model studies have been carried out to estimate littoral drift at the proposed site of Ajanur fishing harbour, Kerala and to examine the likely changes in the coastline due to the proposed northern and southern breakwaters. Following are the main conclusions of the model studies:

1. The annual southward and northward transports are computed to be 0.531 million cum and 0.118 million cum respectively with the net and the gross transports being 0.413 million cum and 0.649 million cum respectively. The net longshore transport is towards south. Also, the major southward transport occurs during SW monsoon.

2. Based on the distribution of annual longshore transport, the transport is confined within a range of 500 m from the shoreline and the southward transport is more than the northward transport. The peak transport occurs at about 50 m from the shoreline and about 75% transport occurs in the range of 50 m to 150 m from shoreline i.e. between +0.0 m to – 3.5 m depth contours.

3. As the net transport is directed towards south, the deposition is expected on the north side of the proposed northern breakwater. After a period of 2, 4, 6, 8 and 10 years, the maximum cross-shore advancement would be about 34 m, 44 m, 52 m, 60 m and 68 m respectively from the prevailing coastline position. The corresponding longshore effect on northern side of the proposed northern breakwater would be felt upto 2500 m.

4. In 10 years period, erosion on the southern side of the proposed southern breakwater would be limited upto 40 m in cross-shore direction and its effect in longshore direction would be extended upto 1500 m in the south of the proposed southern breakwater.

5. Appropriate coastal protection measures need to be adopted on the southern coastline of Ajanur.

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TABLE 1(A) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION OFF AJANUR SOUTH-WEST MONSOON (JUN-SEPT)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	0.56
22.5	0.09	0	0.18	0	0	0	0	0	0	0.27
45	0	0	0.12	0	0	0	0	0	0	0.12
67.5	0	0	0.12	0	0.13	0	0	0	0	0.25
90	0	0.09	0.07	0	0.08	0.07	0	0	0	0.31
112.5	0	0	0.17	0.15	0	0.12	0	0	0	0.44
135	0.14	0.11	0.18	0.37	0.29	0.34	0	0.23	0	1.67
157.5	0.22	0.25	0.42	0.05	0.19	0.21	0	0.23	0.03	1.6
180	0.06	0.27	0.4	0.66	0.13	0.15	0.06	0.41	0.18	2.32
202.5	0.3	0.15	0.51	0.34	0.24	0.2	0.21	0.23	0	2.17
225	0.51	1.08	1.49	1.59	1.11	0.93	0.71	0.33	0.21	7.97
247.5	0.58	2.02	2.09	3.72	1.63	1.72	0.82	1.17	0.71	14.46
270	1.43	5.03	4.48	5.58	4.8	6.08	3.15	4.19	2.91	37.66
292.5	0.84	2.47	3.89	4.11	3.01	2.94	1.15	1.27	1.65	21.33
315	0.14	0.88	1.16	2.09	1.07	0.72	0.04	0.21	0.48	6.77
337.5	0.18	0.6	0.33	0.36	0.08	0.08	0	0	0	1.63
360	0.3	0.07	0	0.09	0	0	0	0	0	0.46

TABLE 1(B) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION OFF AJANUR NORTH-EAST MONSOON (OCT-JAN)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	0.86
22.5	1.95	2.41	0.95	1.06	0.28	0.16	0	0.1	0	6.91
45	2.22	2.6	1.9	1.81	0.04	0.24	0	0.1	0.11	9.03
67.5	1.88	2.71	1.94	0.75	0.33	0.22	0.14	0	0	7.96
90	2.69	3.23	1.71	0.84	0.19	0.43	0.07	0	0	9.17
112.5	1.55	2	0.98	0.8	0.08	0.35	0.1	0	0	5.87
135	0.56	1.45	0.61	0.48	0.03	0.44	0.1	0	0	3.67
157.5	0.52	0.78	0.99	0.51	0.09	0.22	0.1	0.03	0	3.26
180	1.19	1.7	1.17	0.97	0.38	0.07	0	0.17	0	5.65
202.5	0.97	0.5	1.03	0.92	0.25	0.21	0.08	0	0	3.97
225	0.5	1.17	0.77	0.65	0.46	0.04	0.13	0	0.1	3.82
247.5	0.9	1.82	1.57	0.83	0.69	0.75	0.1	0	0	6.67
270	0.65	1.82	1.31	1.5	0.17	0.41	0	0	0	5.87
292.5	1.21	1.48	1.63	0.67	0.13	0.19	0	0.1	0	5.41
315	1.15	2.04	0.99	0.47	0.34	0	0	0	0	4.98
337.5	1.96	2.77	1.61	0.8	0.11	0.1	0	0	0	7.35
360	2.51	3.58	1.73	1.37	0.12	0.22	0	0	0	9.53

TABLE 1(C): FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION OFF AJANUR NON-MONSOON (FEB-MAY)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	1.14
22.5	2.3	2.82	1.12	1.01	0.36	0.1	0.16	0.12	0.05	8.04
45	2.1	1.4	0.89	0.38	0.13	0.17	0.37	0.37	0	5.81
67.5	0.62	1.34	0.22	0.04	0	0.22	0	0.15	0	2.59
90	0.87	1.48	0.47	0.6	0	0	0	0.28	0	3.69
112.5	0.84	1.33	0.6	0.4	0	0	0	0.05	0	3.21
135	1.13	1.9	0.86	0.26	0.01	0	0	0.25	0	4.41
157.5	1.58	1.03	1.62	0.62	0.25	0.11	0.04	0.04	0	5.32
180	1.06	1.98	0.88	0.76	0.07	0.07	0.17	0.1	0	5.08
202.5	0.54	0.55	0.96	0.95	0.05	0.16	0.05	0	0	3.25
225	0.98	1.09	0.4	0.61	0.34	0.15	0.26	0.12	0.12	4.07
247.5	0.74	1.02	1.13	1.24	0.23	0.11	0	0.1	0.03	4.61
270	1.3	2.1	0.81	1.19	0.07	0.48	0	0.11	0.08	6.15
292.5	1.68	2.07	1.24	0.4	0.33	0.27	0	0	0	5.99
315	3.45	3.18	1.57	0.85	0.45	0.16	0	0	0	9.64
337.5	3.57	4.88	2.78	1.02	0.04	0.15	0	0.19	0.11	12.73
360	4.78	4.99	2.28	1.1	0.31	0.12	0.3	0.2	0.18	14.25

TABLE 1(D) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION OFF AJANUR ENTIRE PERIOD (JAN-DEC)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	6.34
22.5	1.3	1.61	0.71	0.62	0.19	0.08	0.05	0.07	0.01	4.64
45	1.29	1.26	0.9	0.67	0.05	0.12	0.11	0.13	0.03	4.57
67.5	0.75	1.26	0.71	0.26	0.14	0.13	0.04	0.04	0	3.35
90	1.06	1.5	0.75	0.48	0.1	0.15	0.02	0.08	0	4.15
112.5	0.72	1.04	0.57	0.43	0.04	0.14	0.03	0.02	0	2.98
135	0.56	1.07	0.56	0.37	0.12	0.24	0.03	0.14	0	3.08
157.5	0.7	0.68	0.96	0.42	0.19	0.18	0.05	0.09	0.01	3.28
180	0.69	1.22	0.78	0.76	0.2	0.1	0.07	0.2	0.06	4.08
202.5	0.54	0.4	0.78	0.68	0.18	0.18	0.1	0.07	0	2.93
225	0.6	1.03	0.86	0.9	0.6	0.36	0.33	0.15	0.13	4.97
247.5	0.66	1.51	1.52	1.86	0.86	0.84	0.31	0.41	0.23	8.21
270	1.02	2.73	2.15	2.76	1.73	2.26	1.01	1.37	0.91	15.94
292.5	1.12	1.88	2.14	1.74	1.17	1.12	0.4	0.46	0.5	10.52
315	1.42	1.91	1.23	1.13	0.61	0.29	0.02	0.07	0.14	6.83
337.5	1.7	2.58	1.5	0.71	0.09	0.1	0	0.05	0.03	6.77
360	2.24	2.65	1.26	0.78	0.14	0.1	0.09	0.06	0.05	7.37

TABLE 2(A) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION AT AJANUR (10m DEPTH) SOUTH-WEST MONSOON (JUN-SEPT)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	1.95
22.5	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0
112.5	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0
157.5	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0
202.5	1.27	1.52	0.44	0.03	0	0	0	0	0	3.26
225	0.87	2.41	4.21	1.76	1.73	1.27	0.21	0	0	12.46
247.5	0.58	2.02	5.81	1.63	1.72	1.99	0.71	0	0	14.46
270	2.27	11.39	14.17	10.75	7.23	10.26	2.91	0	0	58.98
292.5	1.38	2.81	3.24	0.76	0.69	0	0	0	0	8.88
315	0	0	0	0	0	0	0	0	0	0
337.5	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0

TABLE 2(B) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION AT AJANUR (10m DEPTH) NORTH-EAST MONSOON (OCT-JAN)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRCETION									CALM %	39.78
22.5	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0
112.5	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0
157.5	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0
202.5	4.4	2.16	0.35	0	0	0	0	0	0	6.91
225	2.66	5.57	3.69	0.99	0.29	0.13	0.1	0	0	13.43
247.5	0.9	1.82	2.4	0.69	0.75	0.1	0	0	0	6.66
270	1.86	4.93	3.48	0.49	0.41	0.1	0	0	0	11.27
292.5	15.19	5.77	0.91	0	0	0	0	0	0	21.87
315	0	0	0	0	0	0	0	0	0	0
337.5	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0

TABLE 2(C) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION AT AJANUR (10m DEPTH) NON-MONSOON (FEB-MAY)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	24.5
22.5	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0
112.5	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0
157.5	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0
202.5	6.76	2.75	0.19	0	0	0	0	0	0	9.7
225	2.58	5.46	2.79	0.79	0.3	0.38	0.12	0	0	12.42
247.5	0.74	1.02	2.37	0.23	0.11	0.1	0.03	0	0	4.6
270	2.98	5.41	2.4	0.67	0.48	0.11	0.08	0	0	12.13
292.5	25.36	9.39	1.64	0.27	0	0	0	0	0	36.66
315	0	0	0	0	0	0	0	0	0	0
337.5	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0

TABLE 2(D) : FREQUENCY OF OCCURANCE (%) OF WAVE HEIGHT & DIRECTION AT AJANUR (10m DEPTH) ENTIRE PERIOD (JAN-DEC)

WAVE HT(m)	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
DIRECTION									CALM %	26
22.5	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
67.5	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0
112.5	0	0	0	0	0	0	0	0	0	0
135	0	0	0	0	0	0	0	0	0	0
157.5	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0
202.5	3.94	2.1	0.32	0.01	0	0	0	0	0	6.37
225	1.83	4.21	3.4	1.13	0.72	0.55	0.13	0	0	11.97
247.5	0.66	1.51	3.38	0.86	0.84	0.72	0.23	0	0	8.2
270	2.14	6.75	6.65	4.02	2.66	3.34	0.91	0	0	26.47
292.5	12.77	5.74	1.89	0.34	0.21	0	0	0	0	20.95
315	0	0	0	0	0	0	0	0	0	0
337.5	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0

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WAVE PROPAGATION STUDIES TO DETERMINE WAVE CLIMATE FOR THE DEVELOPMENT OF FISH LANDING FACILITIES AT AJANUR, DISTRICT KASARAGOD, KERALA

Technical Report No. **October 2016**

1. INTRODUCTION

Harbour Engineering Department, Government of Kerala has a proposal to develop a fishing harbour at Ajanur. Ajanur village is situated about 15 km south of Kasaragod district at Latitude 12.33^0 and longitude 75.18^0 on the west coast of India in Kerala state Figure 1. Wave tranquility studies to assess wave disturbance in the harbour and the study of littoral movement and shoreline changes, were referred to CW&PRS. The report of the wave tranquility studies is presented.

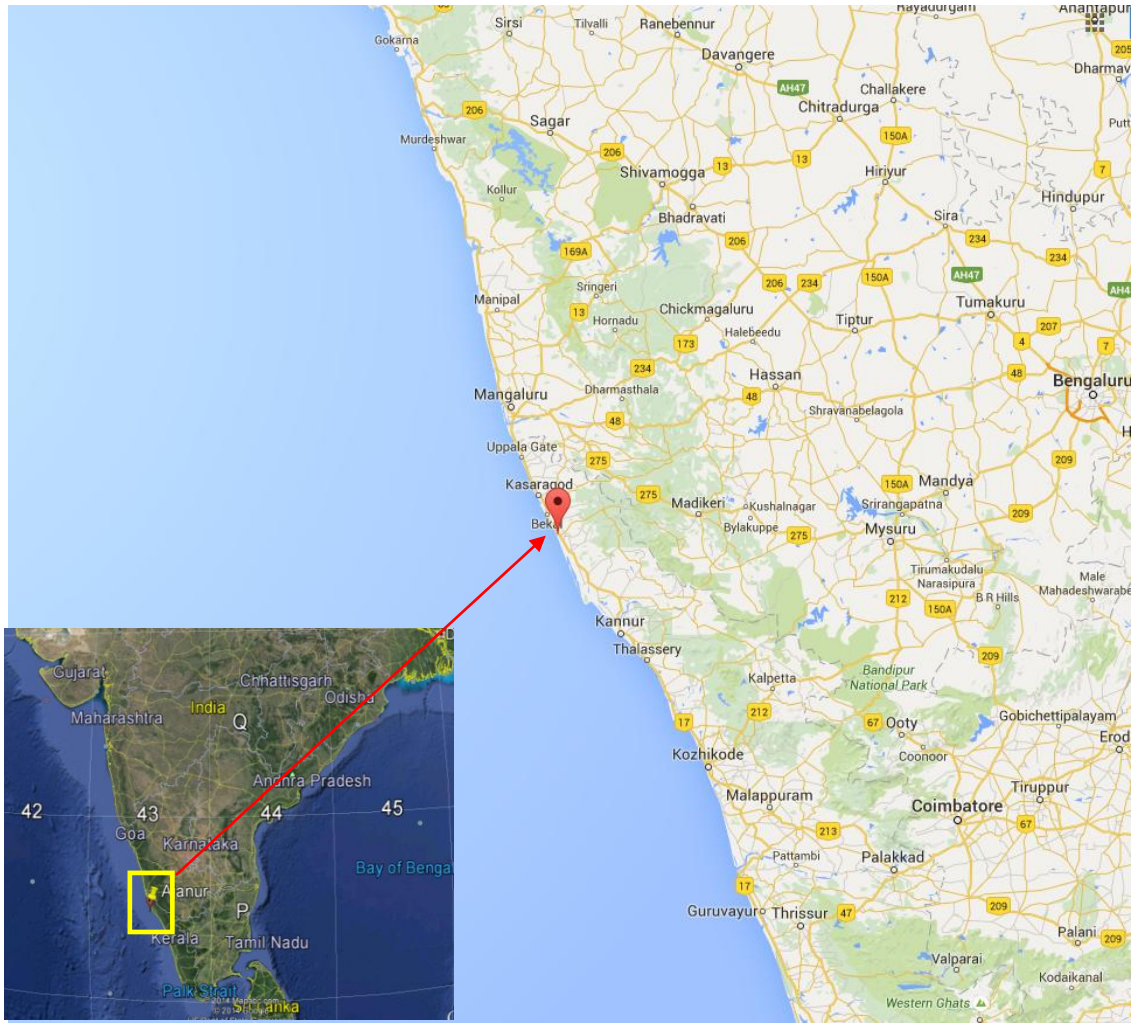


Figure 1 index map of Ajanur, Kasargod, Kerala

2. SCOPE OF STUDIES

Mathematical model studies for wave tranquility were carried out in two stages:

1. Transformation of wave height and wave direction from deep water to 10 m depth using spectral wave model MIKE 21- SW.
2. Simulation of wave propagation in the harbor to obtain wave height distribution in the harbor using MIKE-21 BW model.

This report pertains to mathematical model studies for wave tranquility for optimizing the harbour layout and to determine the near shore wave climate in the vicinity of AJANUR village.

3. WAVE DATA IN DEEP SEA

Near shore wave data is required for simulation of wave heights in the harbour/port. Instrumentally recorded wave data at the site over a period of several years, if available, is best suited for this purpose. However, if such data is not available, the near shore wave climate can be obtained by transforming the offshore wave data to the near shoe locations using the mathematical modeling technique. Visually observed offshore wave data as reported by India Meteorological Department (IMD) observed from ships plying in deep waters off AJANUR (Latitude 10^0 N to 15^0 N, Longitude 70^0 E to 75^0 E) for a period of 33 years i.e. 1968 to 2000 were analyzed. The frequency distribution of wave heights from different directions averaged during different seasons and entire year for the above offshore data is given in Table 1 to Table 4. Corresponding wave rose diagrams are presented in Figure 2, Figure 3, Figure 4 & Figure 5. It has already been established that the wave height based on ship observed data closely corresponds to significant wave height, which represents average energy of the random wave train.

The Table 1 shows frequency of occurrence of wave for South West monsoon from all the directions. The predominant wave directions in this season are from the WNW to SW quadrant. The Table 2 shows the frequency of occurrence of waves for North East Monsoon from all the directions. It is seen that waves with similar frequency occur from almost all direction. The Table 3 shows frequency of occurrence of wave for Non monsoon season from all the directions. It is seen that waves with similar frequency occur from almost all direction. The Table 4 shows frequency of occurrence of wave for the Entire Year Period from all the directions. The predominant wave directions are from the SW to North quadrant. Maximum waves of 4.5m only have been considered in these visually observed wave data sets.

Table 1 Percentage occurrence of Wave height & direction off Ajanur for South-West monsoon (June-Sept)

Wave Ht (m) / Direction	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	Total
									Calm%	0.59
22.5	0.09	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.27
45.0	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.12
67.5	0.00	0.00	0.12	0.00	0.13	0.00	0.00	0.00	0.00	0.25
90.0	0.00	0.09	0.07	0.00	0.08	0.07	0.00	0.00	0.00	0.31
112.5	0.00	0.00	0.17	0.15	0.00	0.12	0.00	0.00	0.00	0.44
135.0	0.14	0.11	0.18	0.37	0.29	0.34	0.00	0.23	0.00	1.66
157.5	0.20	0.25	0.42	0.05	0.19	0.21	0.00	0.23	0.03	1.58
180.0	0.06	0.27	0.40	0.66	0.13	0.15	0.06	0.41	0.18	2.32
202.5	0.30	0.15	0.51	0.34	0.24	0.20	0.21	0.23	0.00	2.18
225.0	0.51	1.08	1.49	1.59	1.11	0.93	0.71	0.33	0.21	7.96
247.5	0.58	2.02	2.09	3.72	1.63	1.72	0.82	1.17	0.71	14.46
270.0	1.43	5.03	4.48	5.58	4.80	6.08	3.15	4.19	2.91	37.65
292.5	0.84	2.47	3.89	4.11	3.01	2.94	1.15	1.27	1.65	21.33
315.0	0.14	0.88	1.16	2.09	1.07	0.72	0.04	0.21	0.48	6.79
337.5	0.18	0.60	0.33	0.36	0.08	0.08	0.00	0.00	0.00	1.63
360.0	0.30	0.07	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.46
Total	4.77	13.02	15.61	19.11	12.76	13.56	6.14	8.27	6.17	100.00

Table 2 Percentage occurrence of Wave height & direction off Ajanur for North-East monsoon period (Oct-Jan)

Wave Ht (m) / Direction	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	Total
									Calm%	0.86
22.5	1.95	2.41	0.95	1.06	0.28	0.16	0.00	0.10	0.00	6.91
45.0	2.22	2.60	1.90	1.81	0.04	0.24	0.00	0.10	0.11	9.02
67.5	1.88	2.71	1.94	0.75	0.33	0.22	0.14	0.00	0.00	7.97
90.0	2.69	3.23	1.71	0.84	0.19	0.43	0.07	0.00	0.00	9.16
112.5	1.55	2.00	0.98	0.80	0.08	0.35	0.10	0.00	0.00	5.86
135.0	0.56	1.45	0.61	0.48	0.03	0.44	0.10	0.00	0.00	3.67
157.5	0.54	0.78	0.99	0.51	0.09	0.22	0.10	0.03	0.00	3.26
180.0	1.19	1.70	1.17	0.97	0.38	0.07	0.00	0.17	0.00	5.65
202.5	0.97	0.50	1.03	0.92	0.25	0.21	0.08	0.00	0.00	3.96
225.0	0.52	1.17	0.77	0.65	0.46	0.04	0.13	0.00	0.10	3.84
247.5	0.92	1.82	1.57	0.83	0.69	0.75	0.10	0.00	0.00	6.68
270.0	0.65	1.82	1.31	1.50	0.17	0.41	0.00	0.00	0.00	5.86
292.5	1.23	1.48	1.63	0.67	0.13	0.19	0.00	0.10	0.00	5.43
315.0	1.15	2.04	0.99	0.47	0.34	0.00	0.00	0.00	0.00	4.99
337.5	1.96	2.77	1.61	0.80	0.11	0.10	0.00	0.00	0.00	7.35
360.0	2.51	3.58	1.73	1.37	0.12	0.22	0.00	0.00	0.00	9.53
Total	22.49	32.06	20.89	14.43	3.69	4.05	0.82	0.50	0.21	100.00

Table 3 Percentage occurrence of Wave height & direction off Ajanur for non-monsoon period (Feb-May)

Wave Ht(m) Direction	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	Total
									Calm%	1.27
22.5	2.30	2.82	1.12	1.01	0.36	0.1	0.16	0.12	0.05	8.04
45.0	2.10	1.40	0.89	0.38	0.13	0.17	0.37	0.37	0.00	5.81
67.5	0.62	1.34	0.22	0.04	0.00	0.22	0.00	0.15	0.00	2.59
90.0	0.87	1.48	0.47	0.60	0.00	0.00	0.00	0.28	0.00	3.70
112.5	0.84	1.33	0.60	0.40	0.00	0.00	0.00	0.05	0.00	3.22
135.0	1.13	1.90	0.86	0.26	0.01	0.00	0.00	0.25	0.00	4.41
157.5	1.56	1.03	1.62	0.62	0.25	0.11	0.04	0.04	0.00	5.27
180.0	1.04	1.98	0.88	0.76	0.07	0.07	0.17	0.10	0.00	5.07
202.5	0.52	0.55	0.96	0.95	0.05	0.16	0.05	0.00	0.00	3.24
225.0	0.96	1.09	0.40	0.61	0.34	0.15	0.26	0.12	0.12	4.05
247.5	0.72	1.02	1.13	1.24	0.23	0.11	0.00	0.10	0.03	4.58
270.0	1.26	2.10	0.81	1.19	0.07	0.48	0.00	0.11	0.08	6.10
292.5	1.68	2.07	1.24	0.40	0.33	0.27	0.00	0.00	0.00	5.99
315.0	3.45	3.18	1.57	0.85	0.45	0.16	0.00	0.00	0.00	9.66
337.5	3.57	4.88	2.78	1.02	0.04	0.15	0.00	0.19	0.11	12.74
360.0	4.78	4.99	2.28	1.10	0.31	0.12	0.30	0.20	0.18	14.26
Total	27.54	33.16	17.83	11.43	2.64	2.27	1.35	2.08	0.57	100.01

Table 4. Percentage occurrence of wave height & direction off Ajanur for entire period (Jan-Dec)

Wave Ht(m) Direction	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	Total
									Calm%	0.89
22.5	1.45	1.74	0.75	0.69	0.21	0.09	0.05	0.07	0.02	5.07
45.0	1.44	1.33	0.97	0.73	0.06	0.14	0.12	0.16	0.04	4.98
67.5	0.83	1.35	0.76	0.26	0.15	0.15	0.05	0.05	0.00	3.60
90.0	1.19	1.60	0.75	0.48	0.09	0.17	0.02	0.09	0.00	4.39
112.5	0.80	1.11	0.58	0.45	0.03	0.16	0.03	0.02	0.00	3.17
135.0	0.61	1.15	0.55	0.37	0.11	0.26	0.03	0.16	0.00	3.25
157.5	0.77	0.69	1.01	0.39	0.18	0.18	0.05	0.10	0.01	3.38
180.0	0.76	1.32	0.82	0.80	0.19	0.10	0.08	0.23	0.06	4.34
202.5	0.60	0.40	0.83	0.74	0.18	0.19	0.11	0.08	0.00	3.13
225.0	0.66	1.11	0.89	0.95	0.64	0.37	0.37	0.15	0.14	5.28
247.5	0.74	1.62	1.60	1.93	0.85	0.86	0.31	0.42	0.25	8.57
270.0	1.13	2.98	2.20	2.76	1.68	2.32	1.05	1.43	1.00	16.55
292.5	1.24	2.01	2.25	1.73	1.16	1.13	0.38	0.46	0.55	10.91
315.0	1.58	2.03	1.24	1.14	0.62	0.29	0.01	0.07	0.16	7.15
337.5	1.90	2.75	1.57	0.73	0.08	0.11	0.00	0.06	0.04	7.24
360.0	2.53	2.88	1.34	0.85	0.14	0.11	0.10	0.07	0.06	8.08
Total	18.25	26.08	18.11	14.99	6.36	6.63	2.77	3.62	2.32	99.97

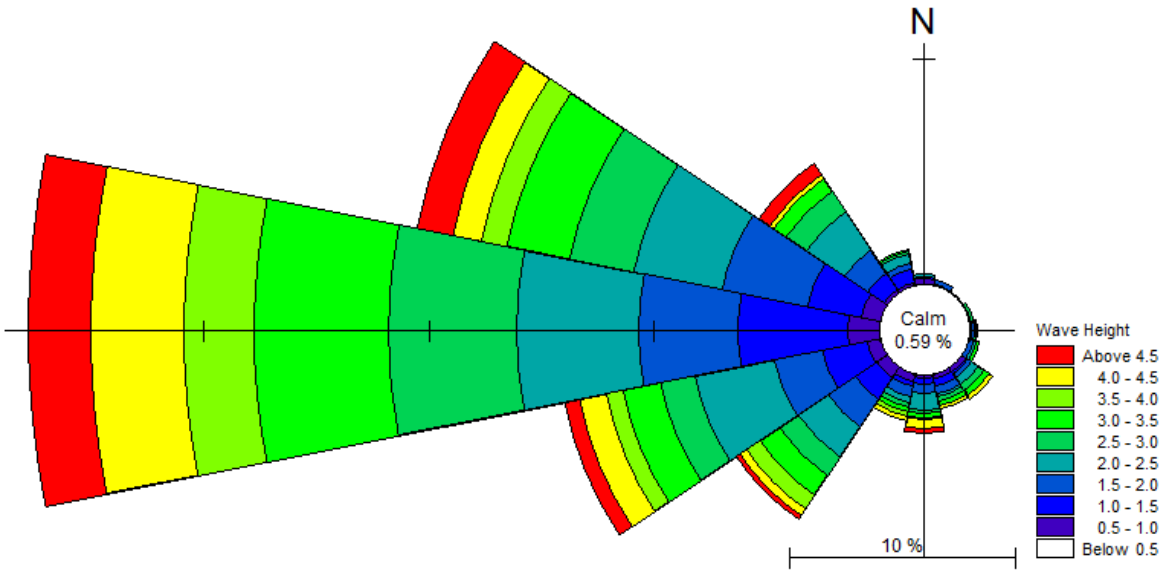


Figure 2. Offshore Wave Rose Diagram for South-West Monsoon

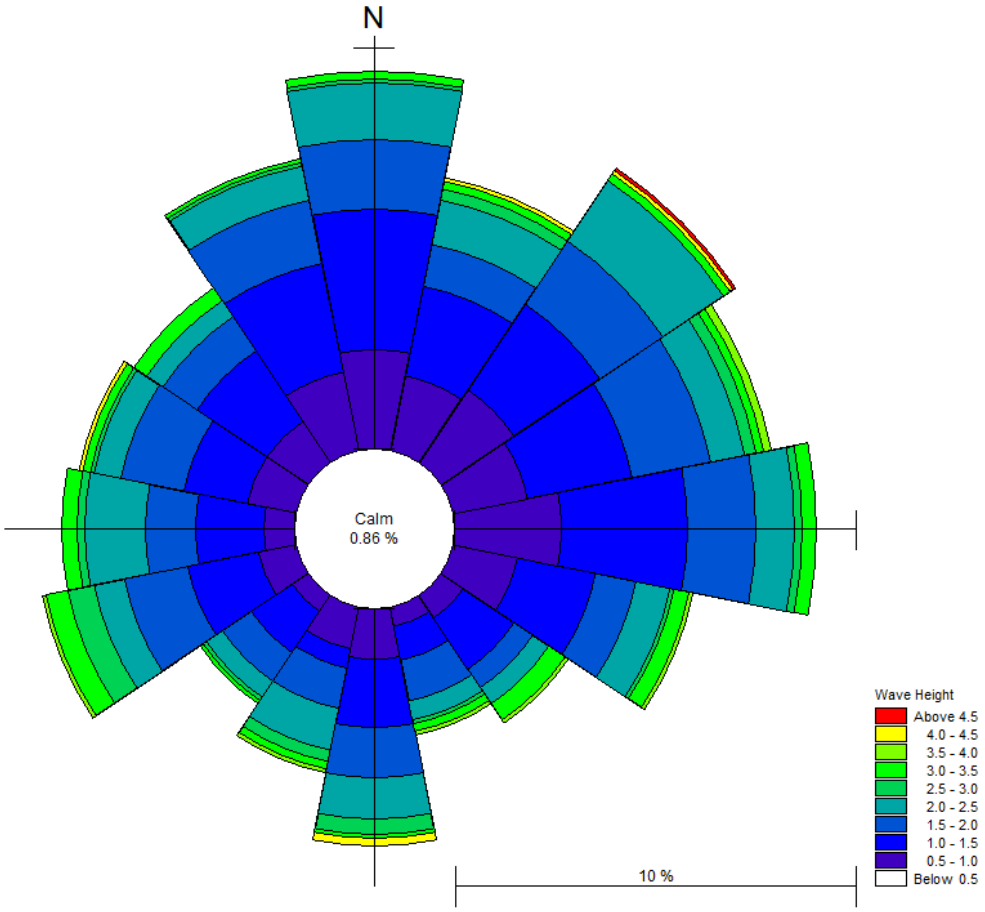


Figure 3. Offshore Wave Rose Diagram for North-East Monsoon

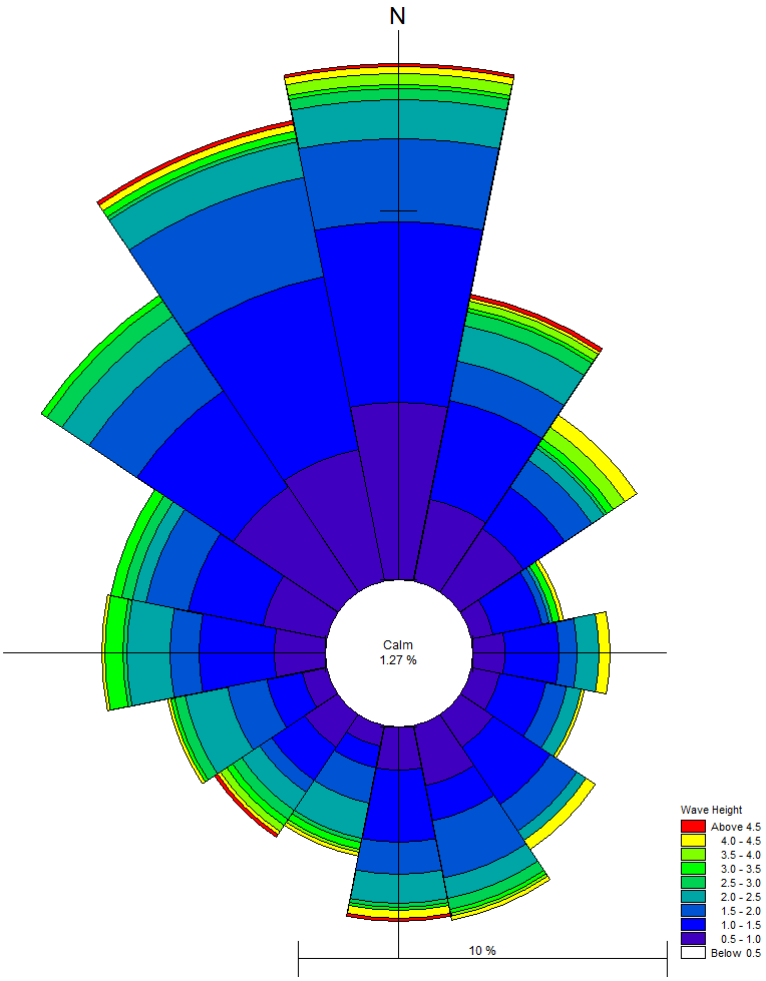


Figure 4. Offshore Wave Rose Diagram for Non Monsoon

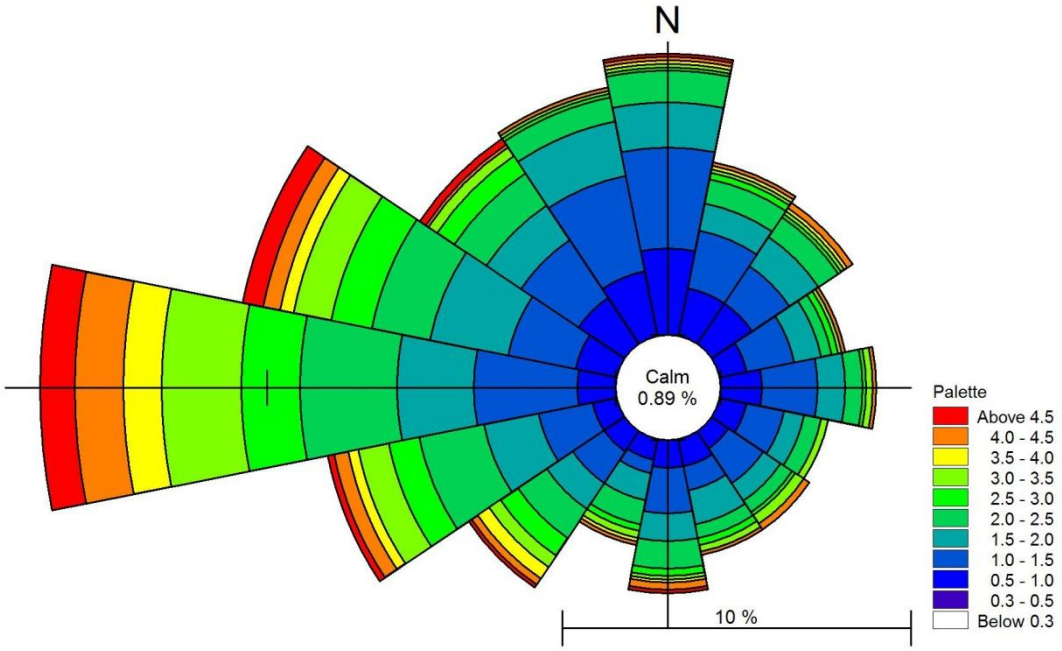


Figure 5. Offshore Wave Rose Diagram for Entire Year

3.1 Tidal Data

The proposed site of development is in the south of Kasaragod. Important tidal levels at KASARAGOD with respect to Chart Datum (As per admiralty chart No. 217 and 2029) are reported to be as under:

MHHW	:	1.4 m
MLHW	:	1.3 m
MSL	:	1.0 m
MHLW	:	0.9 m
MLLW	:	0.4 m

This indicates that the maximum tidal range in the study area is of the order of 1.0 m. Tidal currents are generally parallel to the coastline and directed northward during flood as well as ebb tide with the maximum magnitude of the order of 0.4 m/s (Littoral drift studies report).

4. MATHEMATICAL MODEL STUDIES

Mathematical model studies for examining the wave conditions in the proposed fishery harbour were carried out in two stages:

(i) Transformation of wave height and wave direction while propagating from deep waters to shallow coastal waters (using MIKE 21 SW software)

(ii) Simulation of wave height in the proposed area of development (using software MIKE 21 BW)

4.1 Wave Transformation from deep sea to nearshore region

As waves travel from deep sea to shallow coastal waters, they undergo changes in direction and height due to the processes of refraction and shoaling. The simulation of wave transformation from deep to shallow waters was carried out using MIKE – 21 SW model. This model is a spectral wind wave model based on unstructured mesh, which takes into account all the important phenomena like wave growth by influence of wind, non linear wave-wave interaction, dissipation due to white capping, bottom friction and depth induced breaking. It can also model diffraction effects due to the presence of large structures like breakwaters, groins etc. The effect of refraction and shoaling of waves due to depth variations and wave current interaction are also considered in the model. The output of the model are the regular wave parameters which include the significant wave height, mean wave period, mean wave direction, directional standard deviation and wave radiation stress. The model simulates the growth, decay and transformation of wind – generated waves and swell in offshore and coastal areas.

The governing equation is the wave action balance equation. In horizontal Cartesian co-ordinates the conservation equation for wave action is

$$\frac{\partial N}{\partial t} + \nabla.(\vec{\nu} N) = \frac{S}{\sigma}$$

where N($\vec{x}$, σ, θ,t) is the action density, t is the time, $\vec{x}$ = (x,y) is the Cartesian co-ordinates, $\vec{\nu}$ = (C_x , C_y , C_σ , C_θ) is the propagation velocity of a wave group in the four dimensional phase space $\vec{x}$, σ and θ. S is the source term for the energy balance equation. ∇ is the four dimensional differential operator in the $\vec{x}$, σ and θ space. The equation is solved using cell–centered finite volume method.

5. THE MODEL STUDIES

An area of about 115 km by 85 km (Figure 6) with an unstructured mesh was considered for studies with MIKE –21 SW model which extends beyond 100m in deep sea. The model was run for the offshore wave directions given in Table 4 for all the incident wave directions and heights.

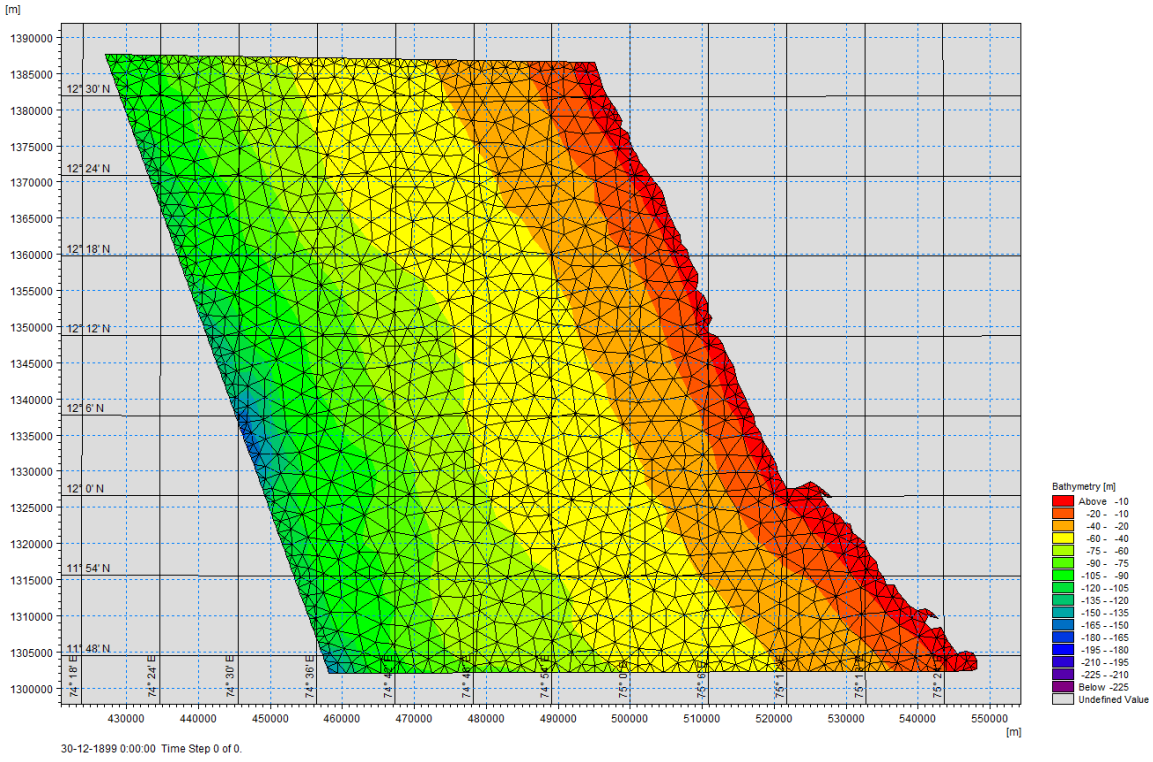


Figure 6. Bathymetry for wave transformation studies

The frequency distribution of wave heights from different directions at the inshore location is given in Table 5 to Table 8. Corresponding wave rose diagrams are presented in Figure 7 to Figure 10.

Table 5. Percentage occurrence of Wave height & direction at Ajanur for South-West monsoon (June-Sept)

Wave Height (m)	**0.30**	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	***TOTAL***
Direction										Calm %	3.03
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
112.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
180	0.39	0.98	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	1.76
202.5	0.59	1.08	2.74	1.08	0.20	0.00	0.00	0.00	0.00	0.00	5.67
225	0.49	1.17	2.93	2.54	0.68	0.20	0.00	0.00	0.00	0.00	8.01
247.5	0.49	2.15	4.20	2.74	2.05	2.64	0.00	0.00	0.00	0.00	14.27
270	2.15	5.18	11.53	12.12	12.61	5.87	1.37	0.00	0.00	0.00	50.83
292.5	0.68	6.55	5.08	3.71	0.39	0.00	0.00	0.00	0.00	0.00	16.42
315	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
337.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	4.79	17.11	26.69	22.39	15.93	8.70	1.37	0.00	0.00	0.00	100.0

Table 6. Percentage occurrence of Wave height & direction at for North-East monsoon period (Oct-Jan)

Wave Height (m)	**0.30**	**0.50**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	***TOTAL***
Direction										Calm %	51.71
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
112.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
180	1.05	1.90	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.14
202.5	2.67	3.04	3.71	1.24	0.57	0.10	0.00	0.00	0.00	0.00	11.32
225	0.95	1.24	0.86	0.48	0.10	0.10	0.00	0.00	0.00	0.00	3.71
247.5	1.14	2.19	1.62	0.76	0.67	0.67	0.00	0.00	0.00	0.00	7.03
270	1.43	3.33	3.04	1.33	0.57	0.00	0.00	0.00	0.00	0.00	9.69
292.5	5.51	5.89	1.52	0.38	0.10	0.00	0.00	0.00	0.00	0.00	13.40
315	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
337.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	12.75	17.59	10.93	4.18	2.00	0.86	0.00	0.00	0.00	0.00	100.00

Table 7. Percentage occurrence of Wave height & direction at Ajanur for non-monsoon period (Feb-May)

Wave Height (m) Direction	0.30	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	*TOTAL*
										Calm %	41.23
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
112.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.5	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
180	3.34	2.55	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.06
202.5	1.76	2.84	2.55	1.37	0.00	0.10	0.00	0.00	0.00	0.00	8.62
225	1.08	1.08	0.39	0.59	0.69	0.49	0.00	0.00	0.00	0.00	4.31
247.5	0.69	0.98	1.08	1.18	0.49	0.00	0.00	0.00	0.00	0.00	4.41
270	2.15	4.11	3.33	0.78	0.29	0.00	0.00	0.00	0.00	0.00	10.68
292.5	9.21	9.99	0.49	0.88	0.00	0.00	0.00	0.00	0.00	0.00	20.57
315	2.74	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.04
337.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	21.06	21.84	9.01	4.80	1.47	0.59	0.00	0.00	0.00	0.00	100.00

Table 8. Percentage occurrence of Wave height & direction at Ajanur for entire period (Jan-Dec)

Wave Height (m) Direction	0.3	0.5	1	1.5	2	2.5	3	3.5	4	4.5	*TOTAL*
										Calm %	32.07
22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
112.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
135	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
157.5	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
180	1.59	1.81	0.52	0.07	0.00	0.00	0.00	0.00	0.00	0.00	3.99
202.5	1.67	2.32	3.00	1.23	0.26	0.07	0.00	0.00	0.00	0.00	8.55
225	0.84	1.16	1.39	1.20	0.49	0.26	0.00	0.00	0.00	0.00	5.35
247.5	0.75	1.77	2.30	1.56	1.07	1.10	0.00	0.00	0.00	0.00	8.56
270	1.90	4.21	5.97	4.74	4.49	1.96	0.46	0.00	0.00	0.00	23.72
292.5	5.12	7.48	2.36	1.66	0.16	0.00	0.00	0.00	0.00	0.00	16.78
315	0.91	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
337.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	12.82	18.85	15.55	10.46	6.47	3.39	0.46	0.00	0.00	0.00	100.00

Table 8 and Figure 10 show the percentage occurrence of wave distribution at 10 m water depth near Ajanur for the entire year. From the above table it can be interpreted that the predominant wave directions are SSW, SW, WSW and West with the percentage occurrence of 8.55, 5.35, 8.56 and 23.72 respectively. The maximum wave height of 3.0 m is observed from West direction. Table 5 shows the percentage occurrence of wave distribution at 10 m depth near Ajanur for South-West Monsoon season. From the above table, it can be interpreted that the predominant wave directions are SW, WSW, West and WNW with the percentage occurrence of 8.02, 14.27, 50.83, and 16.42 respectively. The maximum wave height of 3.5 m is observed from West direction. Table 6 shows the percentage occurrence of wave distribution at 10 m depth near Ajanur for the North-East Monsoon season. From the above table it can be interpreted that the predominant wave directions are SSW, SW, WSW, West and WNW with the percentage occurrence of 11.32, 3.71, 7.03, 9.7 and 13.4 respectively. The maximum wave height of 2.5 m is observed from West-South-West direction. Table 7 shows the percentage occurrence of wave distribution at 10 m depth near Ajanur for the Non-Monsoon season. From the above table, it can be interpreted that the predominant wave directions are SSW, SW, WSW and West with the percentage occurrence of 8.62, 4.31, 4.41 and 10.68 respectively. The maximum wave height of 2.5 m is observed from South-West direction.

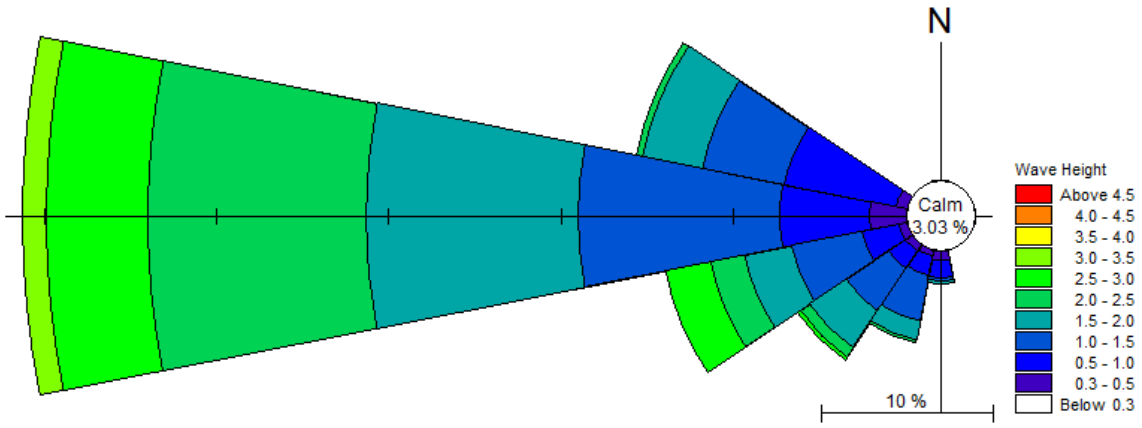


Figure 7. Wave Rose Diagram near Ajanur for South West Monsoon (Jun. – Sept.)

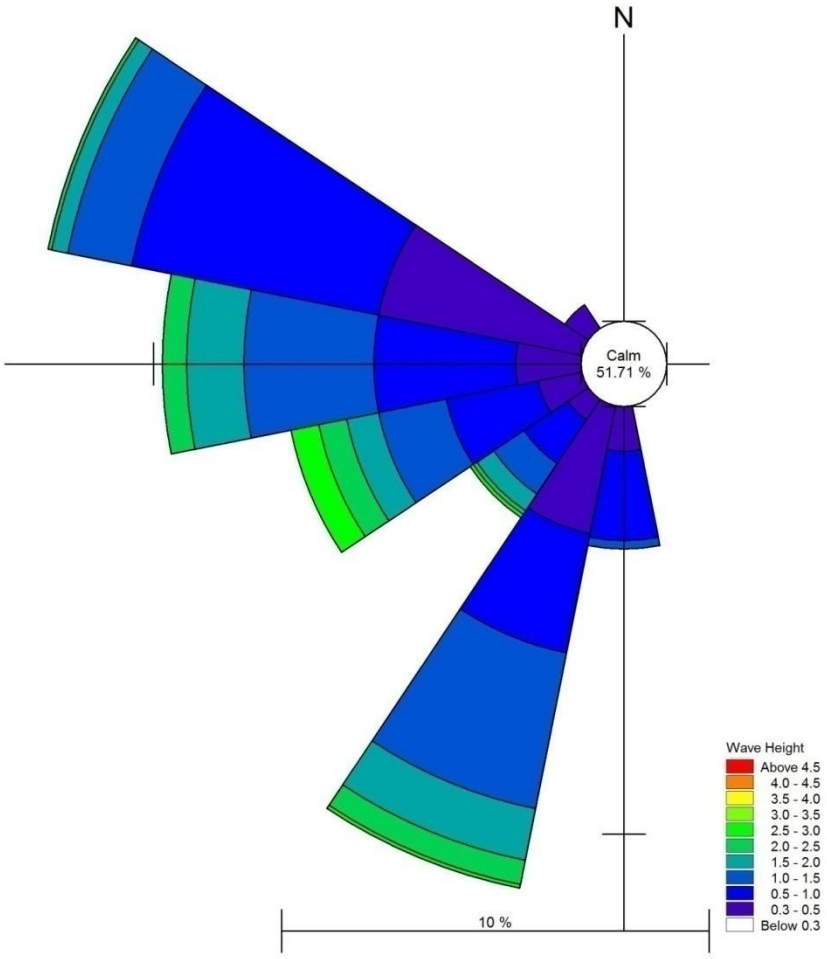


Figure 8. Wave Rose Diagram near Ajanur for North East Monsoon (Oct. – Jan.)

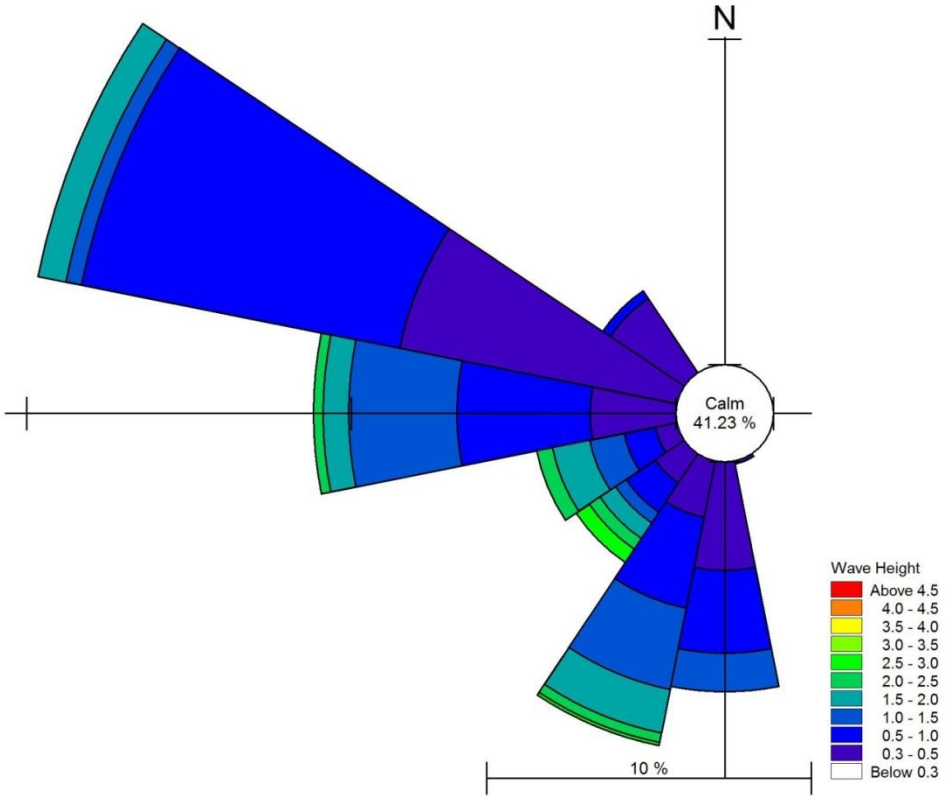


Figure 9. Wave Rose Diagram near Ajanur for Non Monsoon (Feb. – May.)

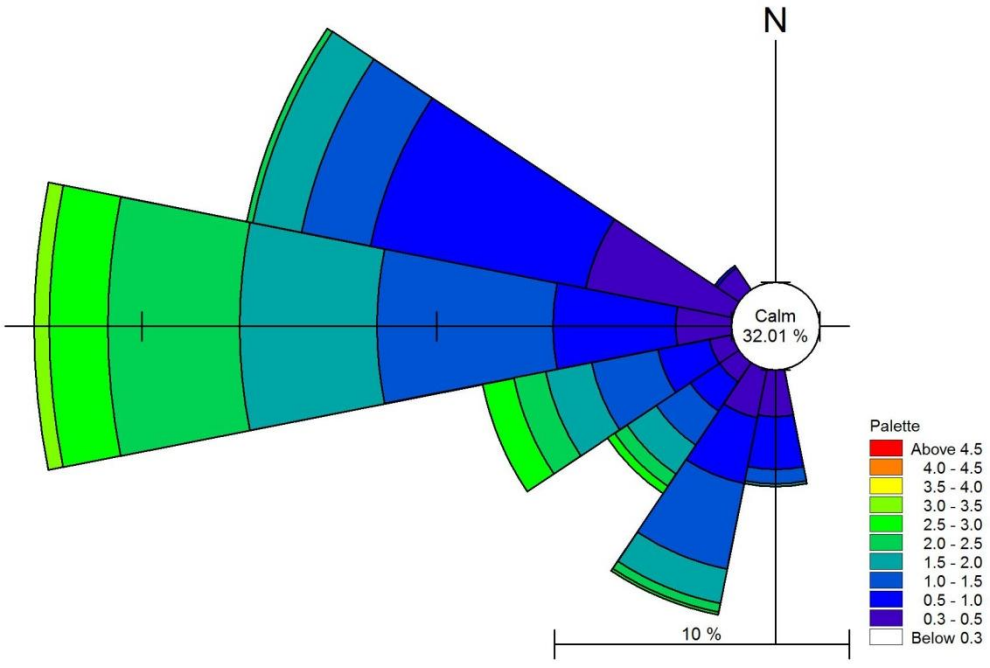


Figure 10. Wave Rose Diagram near Ajanur for Entire Year (Jan – Dec.)

Hence the wave conditions as input to the wave tranquility studies with MIKE 21 BW model have been shortlisted based on the percentage of occurrence are tabulated below in Table 9.

Table 9. Input Wave Conditions for Wave Tranquility Studies.

Incident Wave Direction	Incident Wave Height
SSW	1.5
SW	2.0
WSW	2.5
WEST	2.5
WNW	1.5

6. PERMISSIBLE WAVE HEIGHTS

The permissible wave disturbance at the berthing place depends on the ship size, mooring & berthing system, method of loading & unloading used at berth and on orientation of the berth with respect to wave direction etc. The acceptable wave heights for different types of vessels recommended by the International Association of Ports and Harbours are given in Table 10.

Table 10. Allowable wave heights near the berths (IPA Norms)

Type of vessels	Acceptable wave heights - H_s(m)	
	Incident angle 0^0 (head on)	Incident angle (45^0 – 90^0)
Conventional general cargo vessels	1.0	0.8
Container vessels	0.5	0.4
Dry bulk carrier 30-100,000 DWT(loading)	1.5	1.0
Dry bulk carrier 30-100,000 DWT(unloading)	1.0	0.8 – 1.0
Tankers 30-200,000 DWT	1.5 - 2.5	1.0 – 1.2

As per IS 4651 (Part V), the wave disturbance within the harbour should not exceed the tranquility conditions given in following Table 11.

Table 11. Allowable wave heights near the berths (IS-4651)

Type of vessels	Approximate acceptable wave heights - H_s(m)	
	At berth	Turning circle
General cargo	0.65	0.90
Bulk cargo	0.90	1.20
Container cargo	0.65	1.20
Dredgers	-	0.45 – 2.0

The wave tranquility studies were carried out assuming a wave tranquility limit of 0.3 m as the tranquility limit for the fishing boats / vessels have not been given in the above table.

7. WAVE TRANQUILITY STUDIES

Mathematical model studies to assess wave tranquility in the harbour basin were carried out using the model MIKE 21 BW. The mean sea levels at Mangalore 1.0m, KASARAGOD 0.89 m, Cannanore 1.02 m have been obtained from admiralty charts. Therefore the tidal level of 0.89 m at KASARAGOD has been considered for the wave tranquility studies using MIKE 21 BW. The model was simulated for all the input wave conditions derived from the wave transformation studies for each harbour Layout suggested.

Initially, the harbour authorities have suggested three different layouts for the studies. MIKE 21 BW model was used to study the wave distribution in the harbour area with all the three Layouts (Layout-1, Layout-2 and Layout-3). During the month of August 2016, Site Visit to the proposed fisheries harbour was made. Based on the discussion at site, project authorities suggested a different layout, which is similar to layout 3. However in the proposed layout (Layout 4), alignment of the northern breakwater is slightly different. This layout was also studied using MIKE 21 BW and results are also discussed in this report.

7.1 Layout 1

Based on the coordinates provided by the project authorities the north breakwater is having a length of 458m. The southern breakwater consists of shore normal breakwater of length 291 m which is extended along shore breakwater of length 395 m. The breakwaters extend up to 4 m to 4.4 m depth (Figure 11). Depths inside the harbour have been considered as -3.0 m. Total length of the southern breakwater works out to be 686 m.

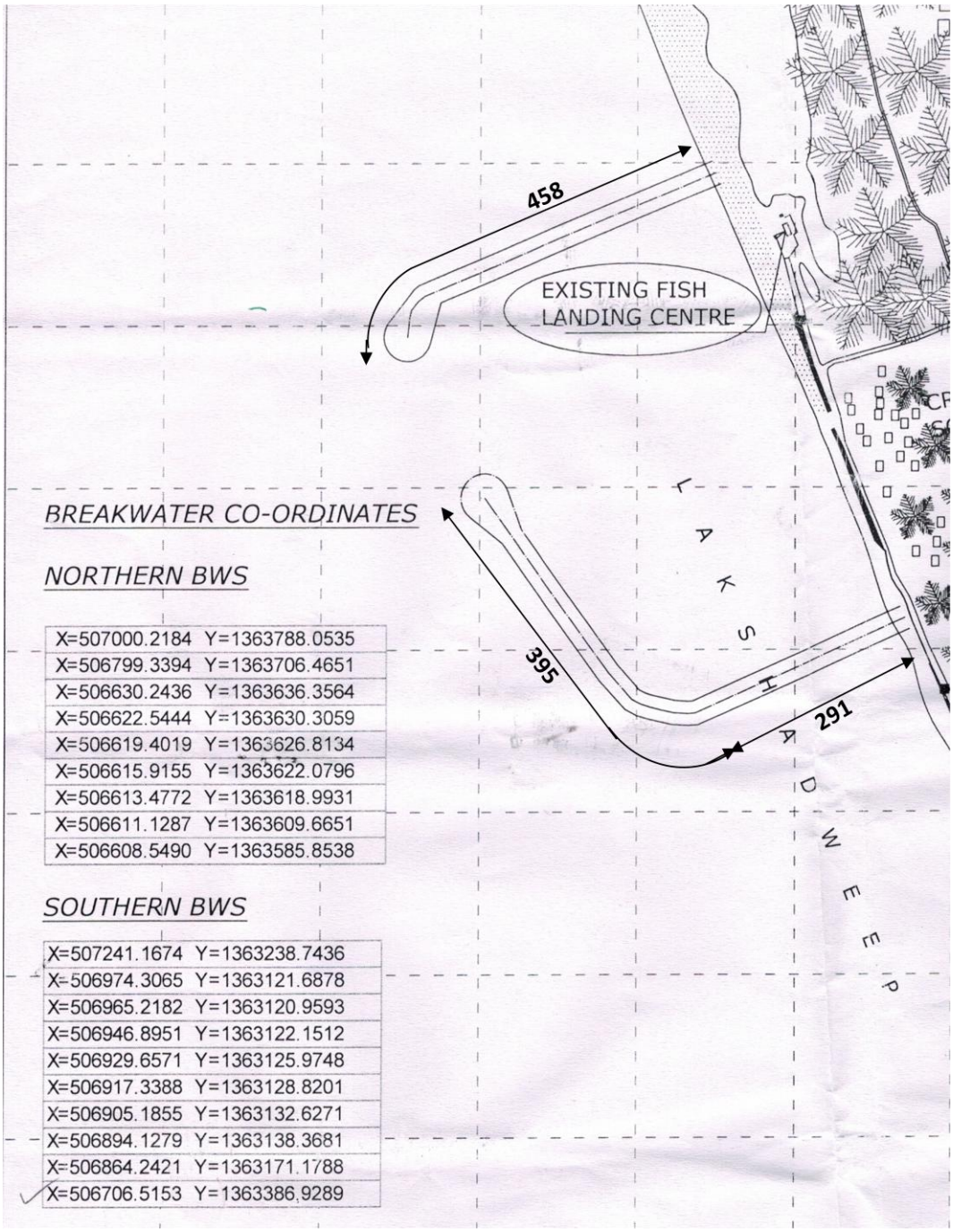


Figure 11. Proposed Layout 1

7.2 Layout 2

Based on the coordinates provided by the project authorities the southern breakwater is having a length of 458m. The northern breakwater consists of shore normal breakwater of length 291 m which is extended along the shore for an additional length of 395 m, making the total length of northern breakwater as 686 m. The breakwaters extend up to 4 m to 4.4 m depth (Figure 12).

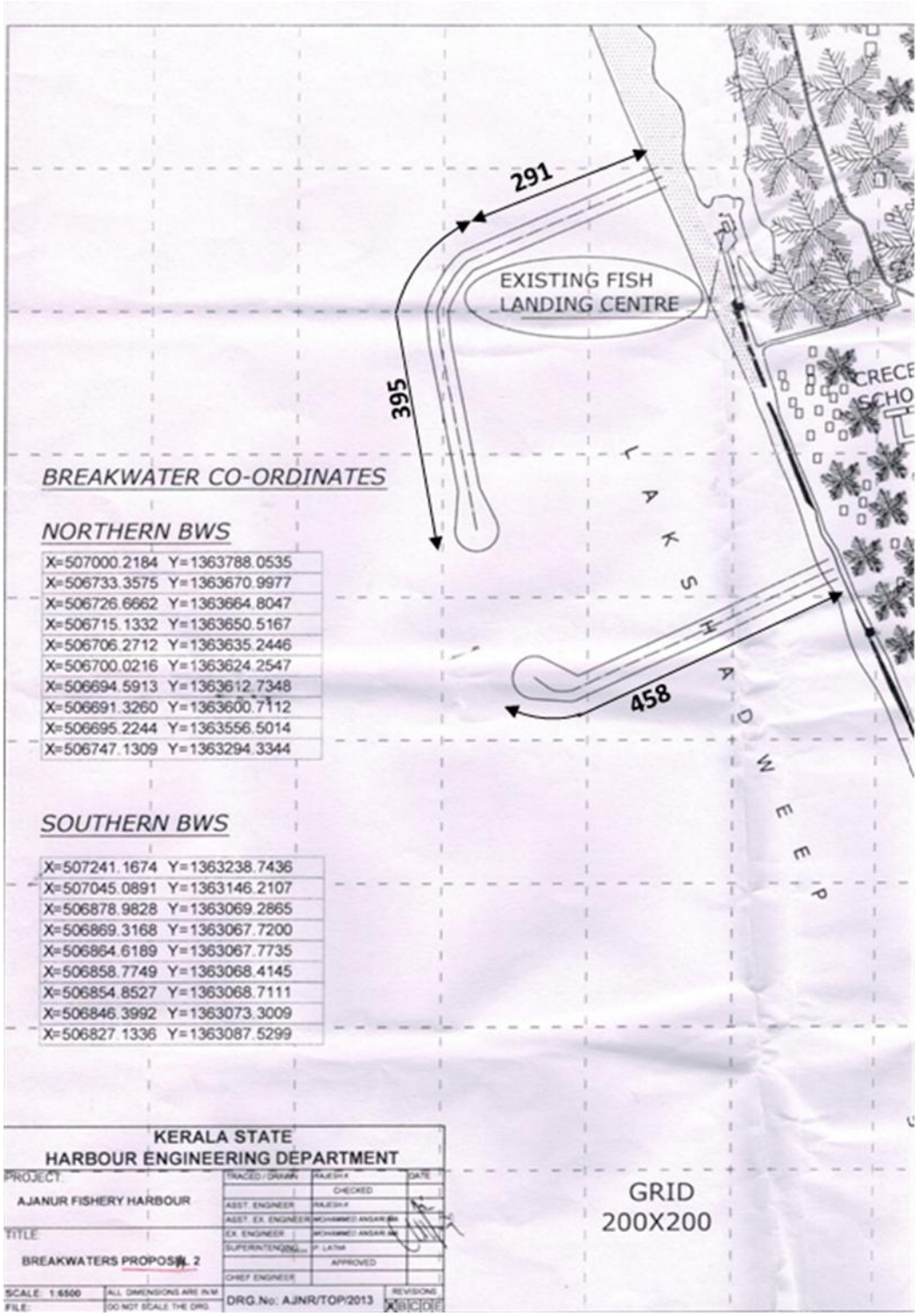


Figure 12. Proposed Layout 2

7.3 Layout 3

Based on the coordinates provided by the project authorities the southern breakwater is having a length of 334 m. The northern breakwater consists of shore normal breakwater of length 291 m which extends along the shore for an additional length of 520 m making the total length of the northern breakwater as 811 m. The breakwaters extend up to 4 m to 4.4 m depth (Figure 13). Depths inside the harbour have been considered as -3.0 m.

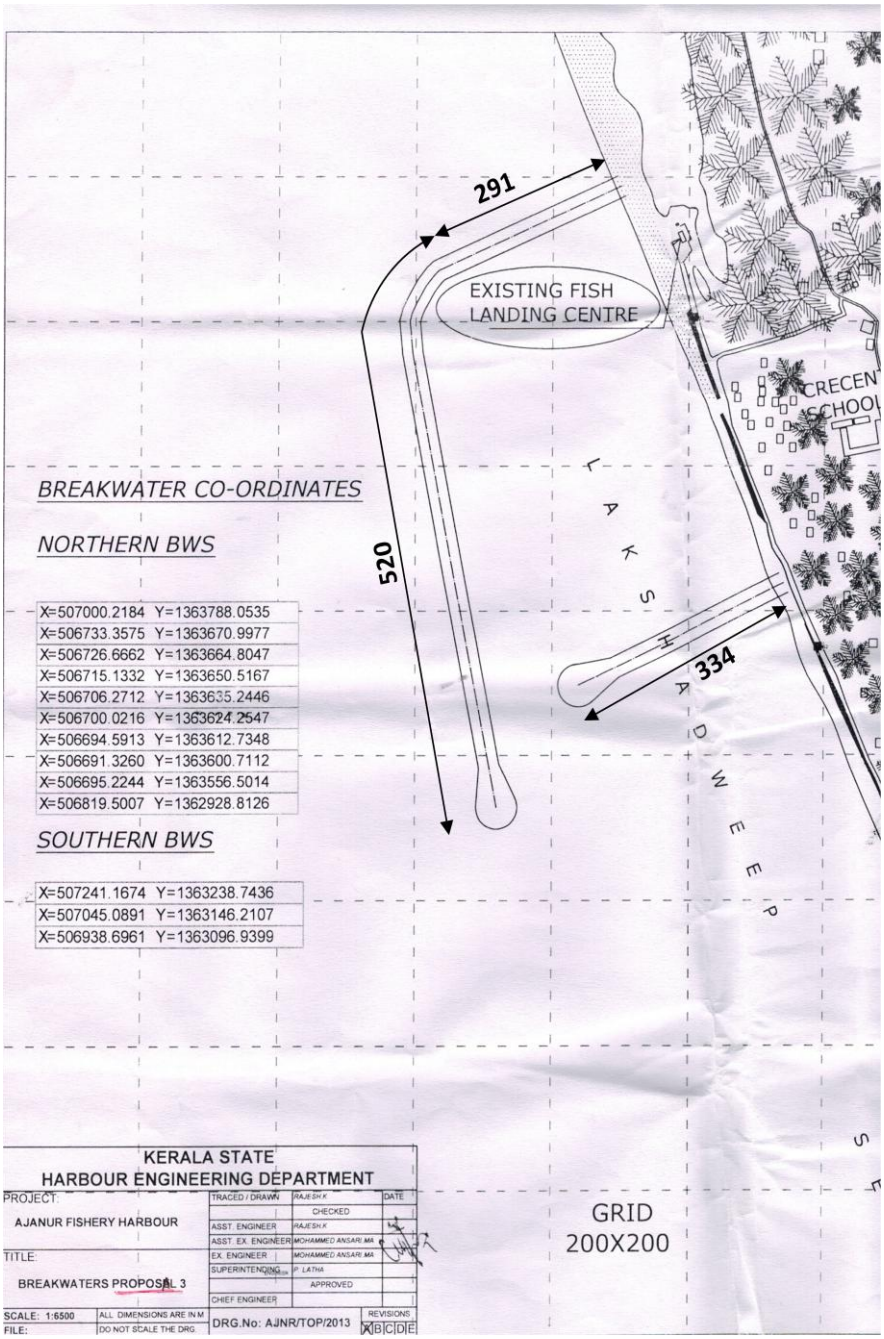


Figure 13. Proposed Layout 3

7.4 Layout 4

This Layout 4 was provided during the site visit to Ajanur, Kerala in August 2016. Based on the coordinates provided by the project authorities the southern breakwater is having a length of 375 m. The northern breakwater with 1000m length started at shore and extends along the shore as shown in Figure 14 below. The breakwaters extend up to 4 m to 4.5 m depth (Figure 14). Depths inside the harbour have been considered as -3.0 m.

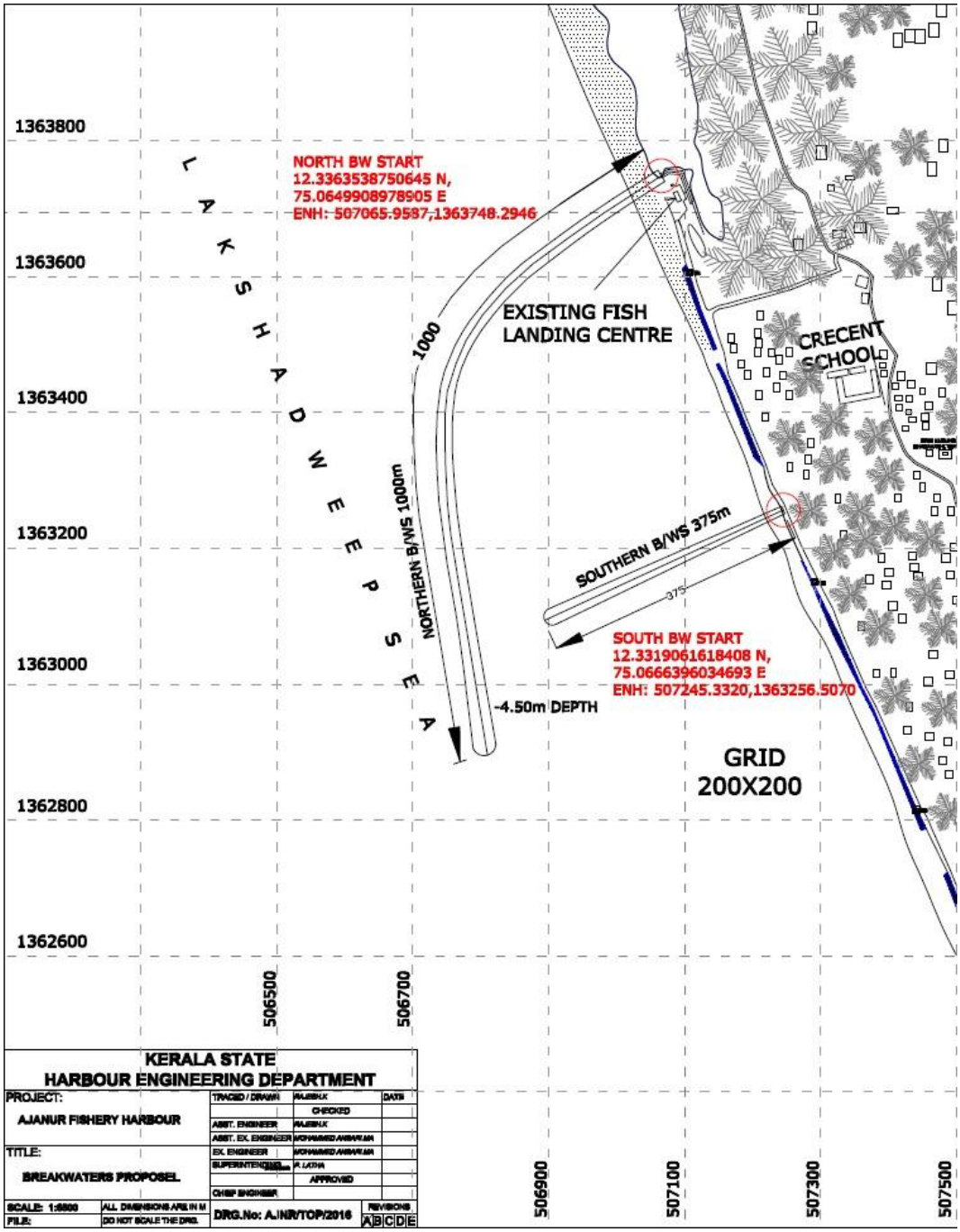


Figure 14. Proposed Layout 4

8. MIKE 21 BW

The Boussinesq Wave model, MIKE 21 BW, is the state-of-the-art numerical model for calculation and analysis of short and long-period waves in ports, harbours and coastal areas. MIKE 21 BW can also be used for detailed modeling of wave-induced current fields, surf zone dynamics and swash zone oscillations. The model is based on the numerical solution of the enhanced Boussinesq equations formulated by Madsen and Sørensen.

MIKE 21 BW is capable of reproducing the combined effects of all important wave phenomena of interest in port, harbour and coastal engineering. These include:

- Shoaling
- Refraction
- Diffraction
- Wave breaking
- Bottom friction
- Moving shoreline
- Partial reflection and transmission
- Non-linear wave-wave interaction
- Frequency spreading
- Directional spreading

9. WAVE PROPAGATION STUDY IN THE AJANUR HARBOUR FACILITY

Different sizes of the coastal areas were considered for wave propagation studies for the waves from different incident wave directions for all the three layouts are given in Table 12. Grid size in each case was 3m X 3m.

Table 12. Wave Height, Wave Direction and Model Size for Different Layouts

Sr. No	Wave Dir.	Wave Ht. (m)	**Layout 1**		**Layout 2**		**Layout 3**		**Layout 4**	
			X dir.	Y dir.	X dir.	Y dir.	X dir.	Y dir.	X dir.	Y dir.
1	SSW	1.5	2850	2700	2850	2700	2250	1800	5100	4500
2	SW	2.0	3000	2400	2400	2400	2100	1500	4200	3600
3	WSW	2.5	4200	4500	3600	2250	2100	1800	4050	4200
4	WEST	2.5	4200	4500	4200	3000	1950	1950	4200	4500
5	WNW	1.5	2850	2400	2700	2700	-	-	-	-

9.1 Studies with Layout 1

Layout 1 as stated earlier consists of north and south breakwaters. The north breakwater is of length 335m. The southern breakwater consists of shore normal breakwater of length 270m which is extended along shore breakwater of length 340m. The breakwaters extend up to 4 m to 4.4 m depth (Figure 11). Bathymetry (Figure 15), surface elevation plot (Figure 16) of the wave propagation for one output is given as representative plot and contours of the wave height in the port for incident wave directions from SSW, SW, WSW, West and WNW are presented below. Wave height distribution plot in the entire study area and zoomed in view of the harbour is given in Figure 17 to Figure 26 respectively for SSW, SW, WSW, West and WNW directions.

9.2 Bathymetry, Surface Water Level and Wave Height Distribution plot for Layout 1

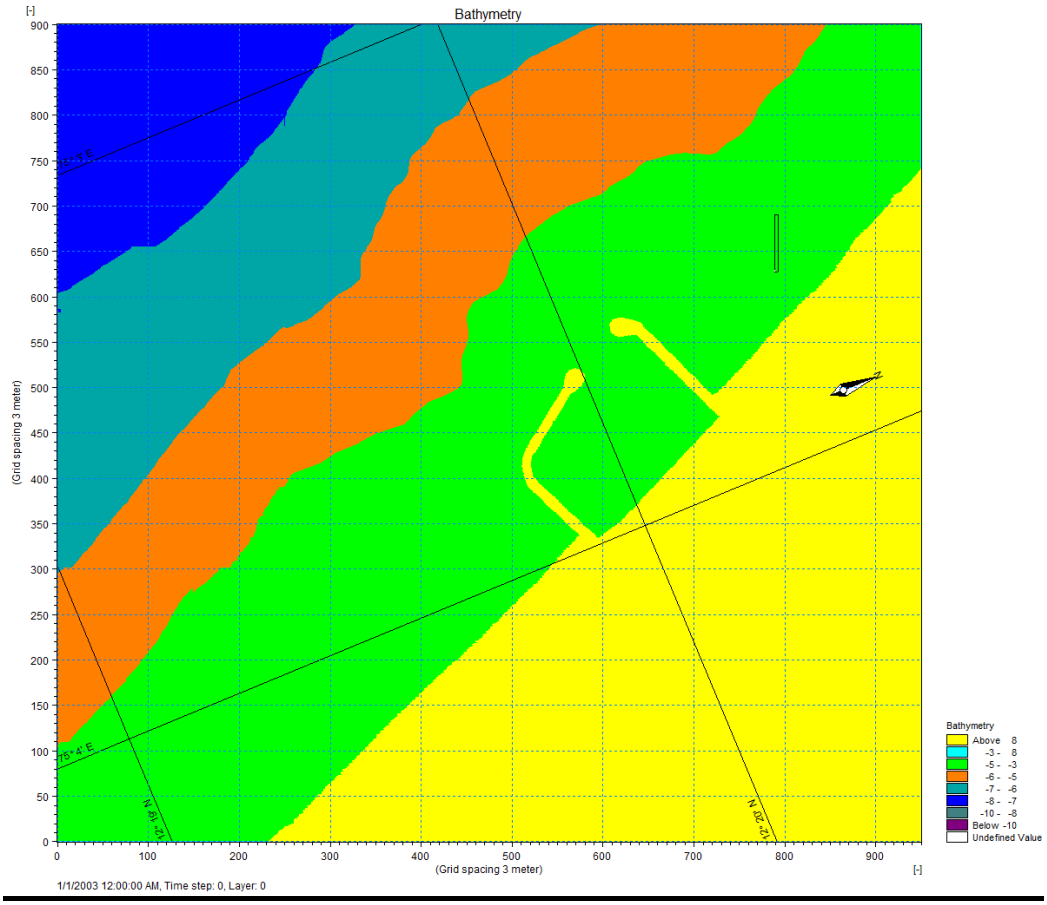


Figure 15. Sample Bathymetry Plot for Layout 1

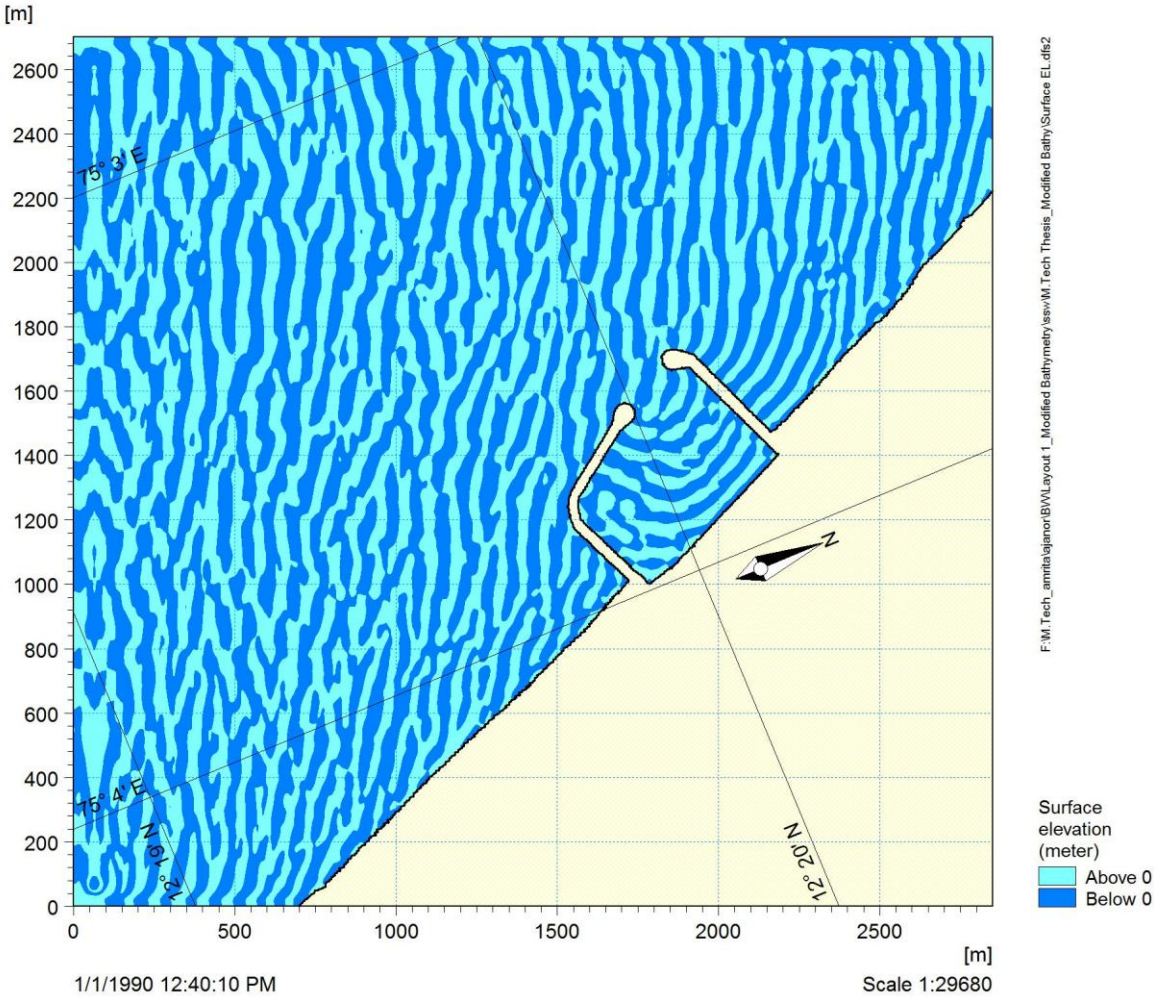


Figure 16. Sample Water Surface Elevation Plot for Layout 1

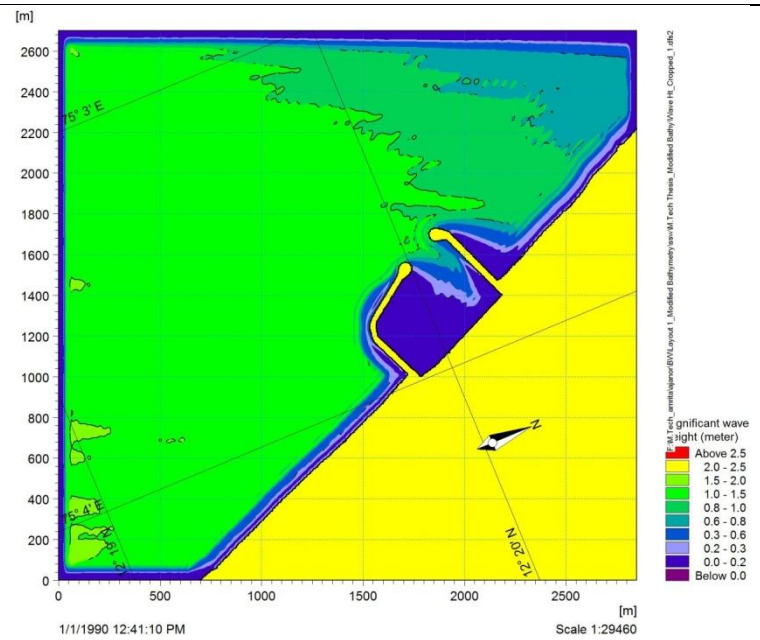


Figure 17. Wave Height Distribution Plot
Wave Direction - SSW, Wave Height - 1.5m

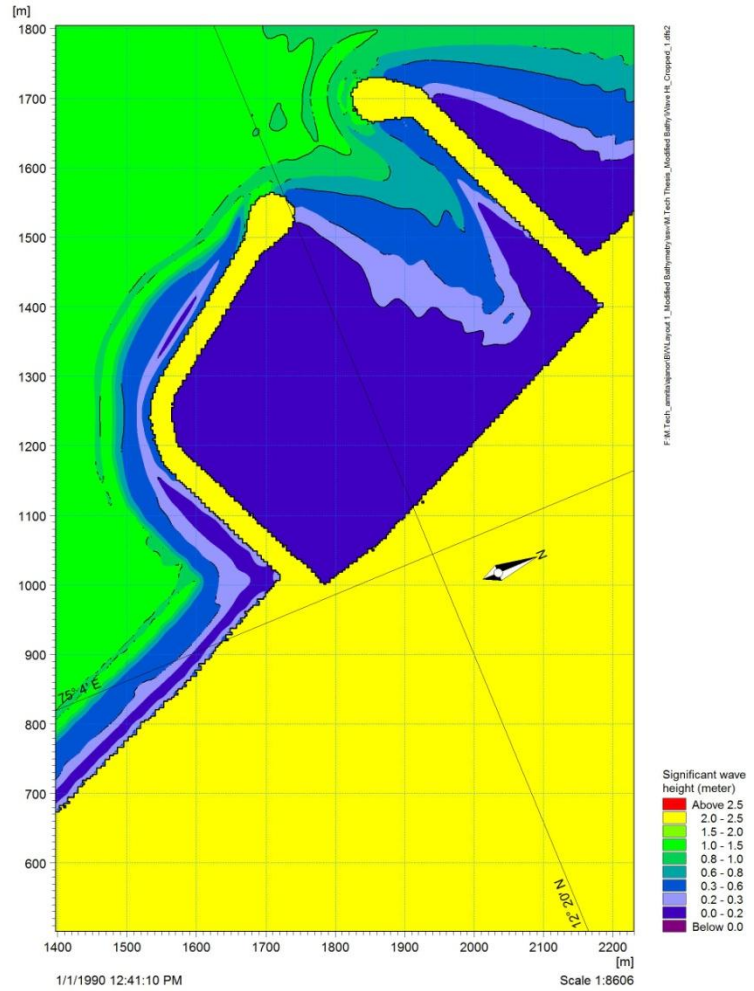


Figure 18. Zoomed View of Figure 17

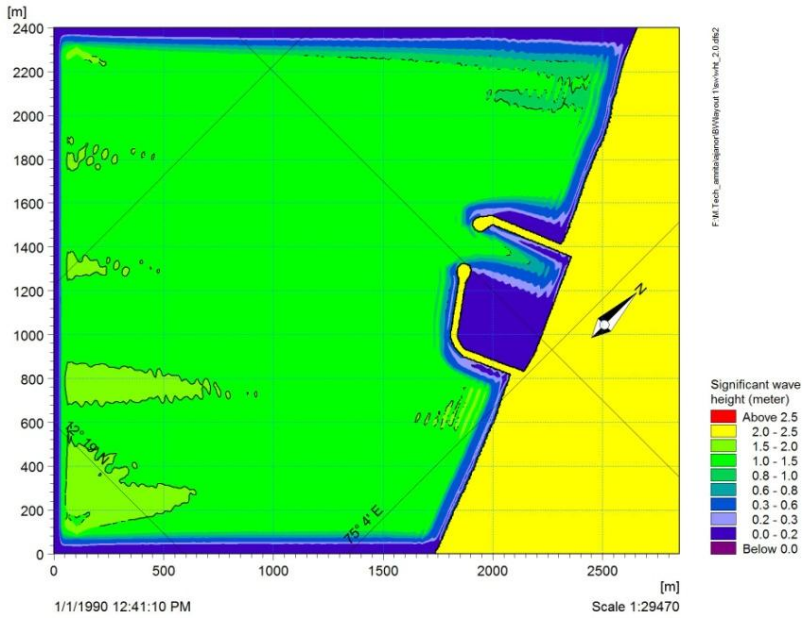


Figure 19. Wave Height Distribution Plot
Wave Direction - SW, Wave Height - 2.0 m

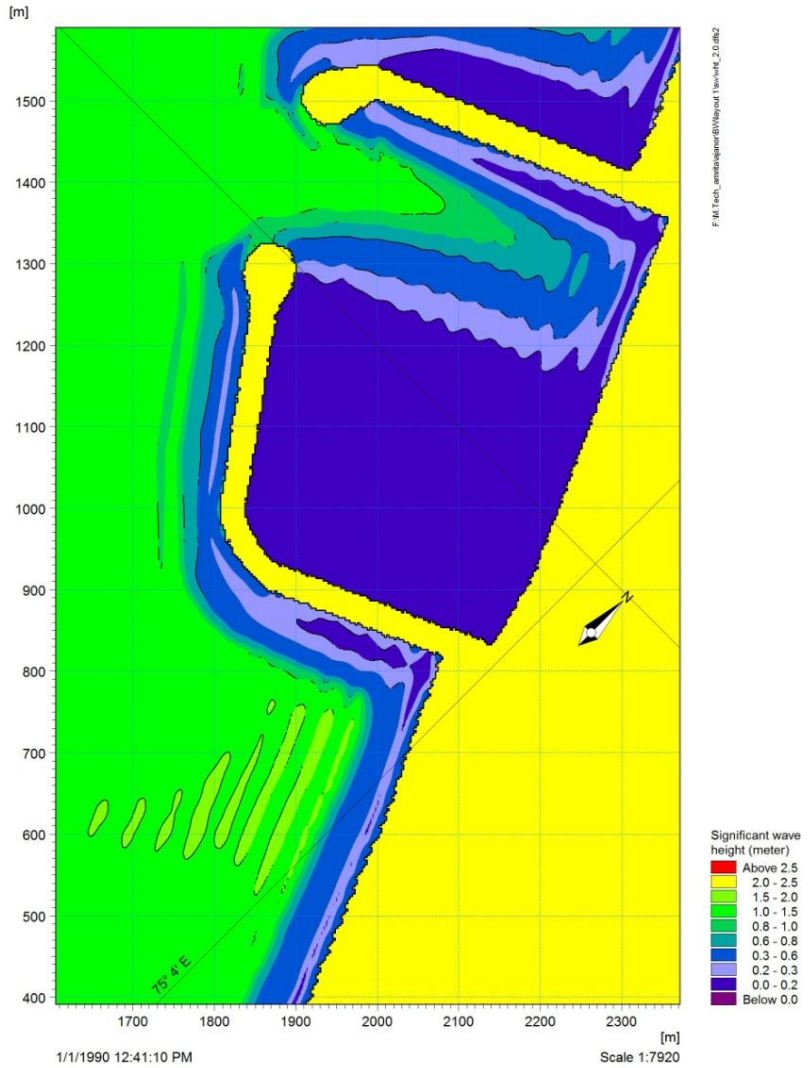


Figure 20. Zoomed in view of Figure 19

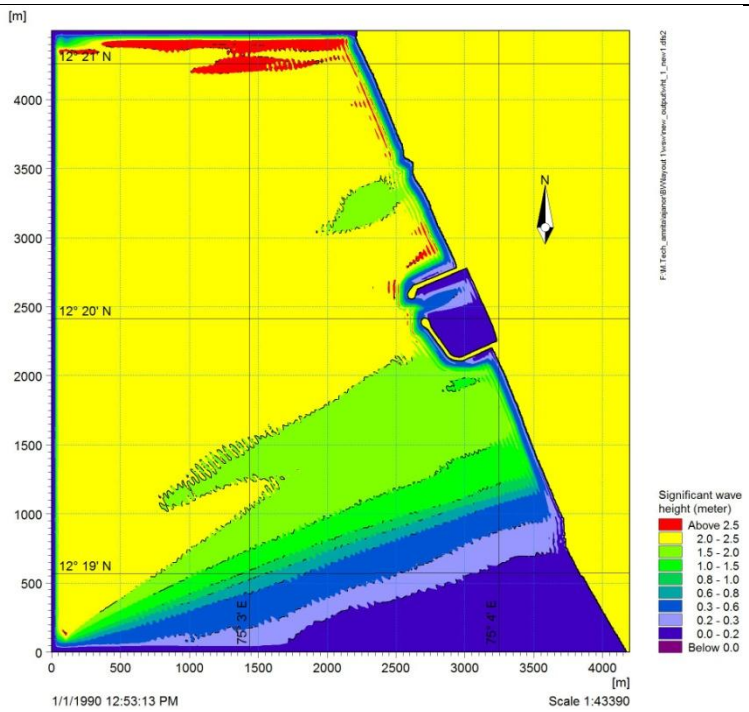


Figure 21. Wave Height Distribution Plot
Wave Direction - WSW, Wave Height - 2.5 m

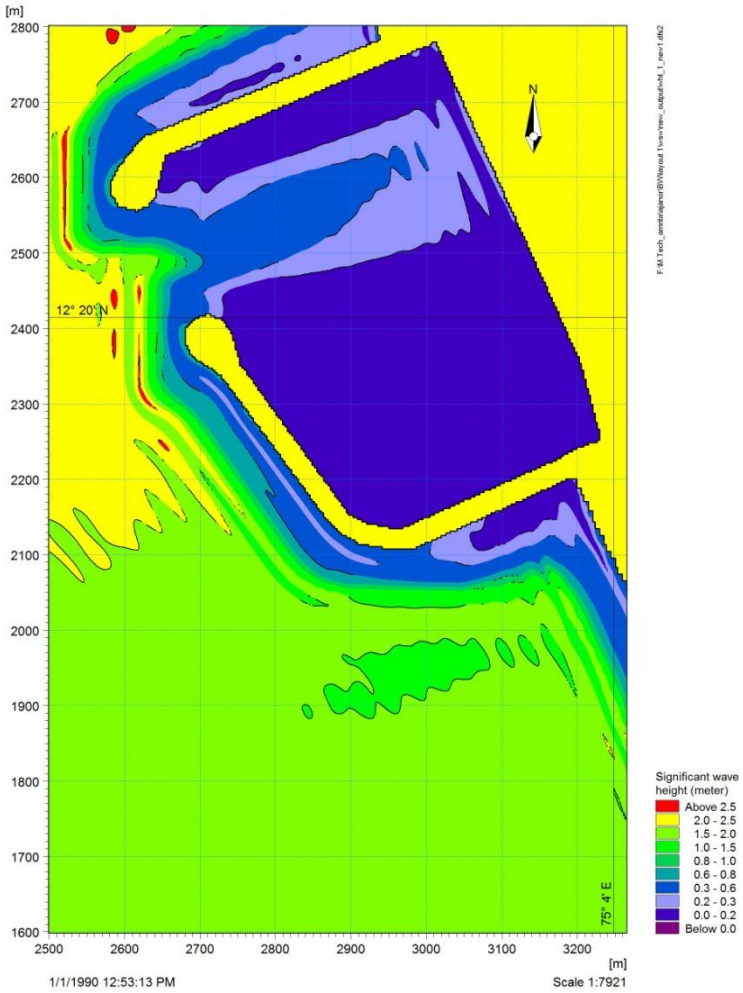


Figure 22. Zoomed in view of Figure 21

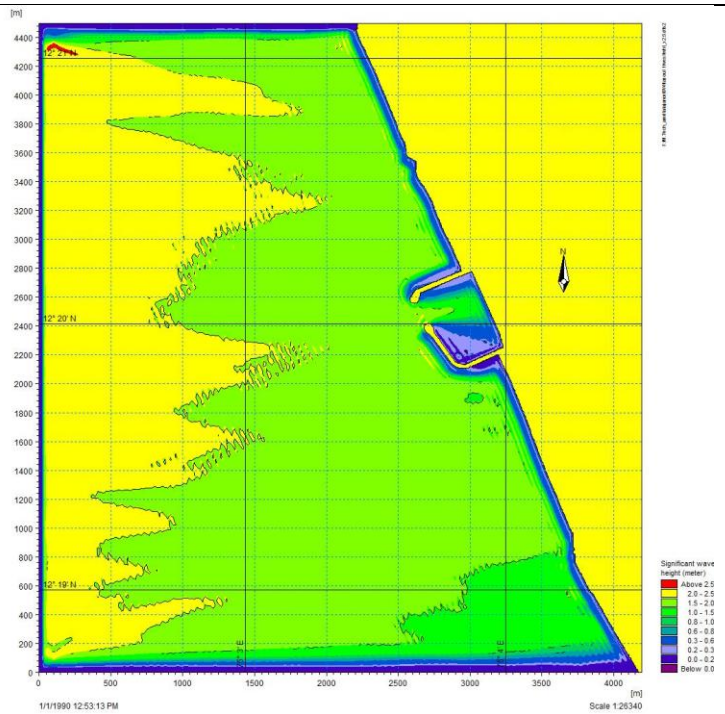


Figure 23. Wave Height Distribution Plot
Wave Direction - West , Wave Height - 2.5 m

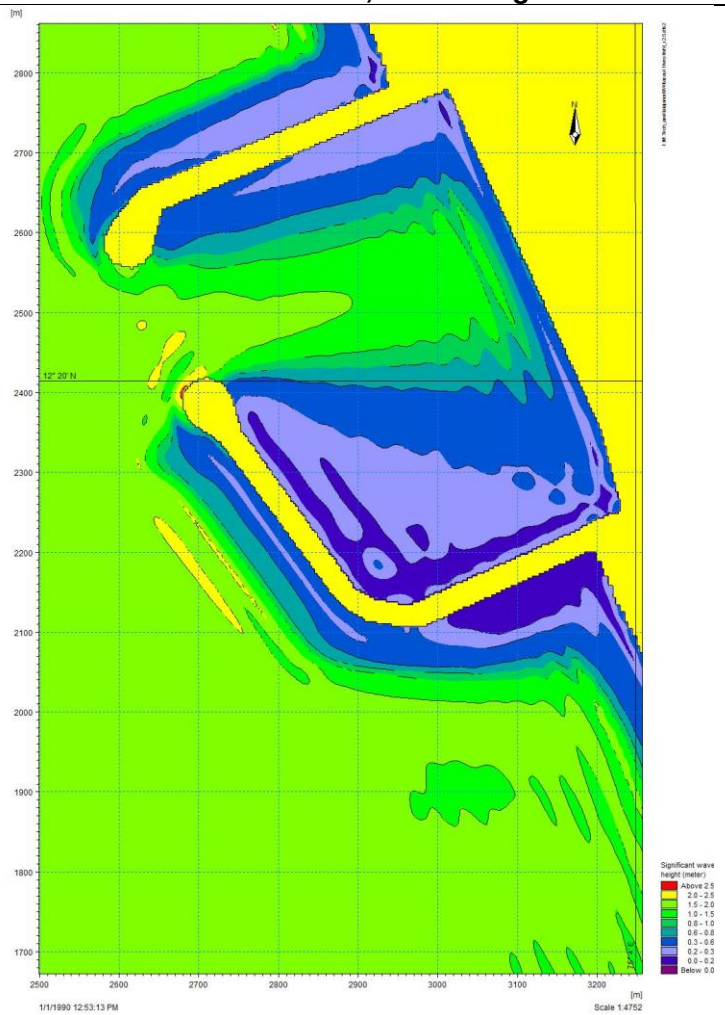


Figure 24. Zoomed in view of Figure 23

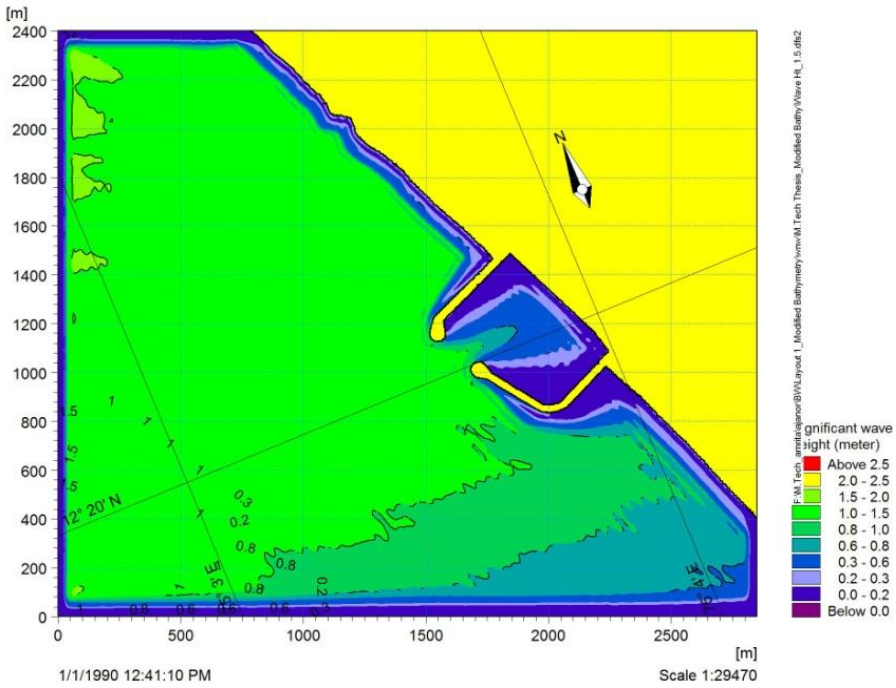


Figure 25. Wave Height Distribution Plot
Wave Direction - WNW , Wave Height - 1.5 m

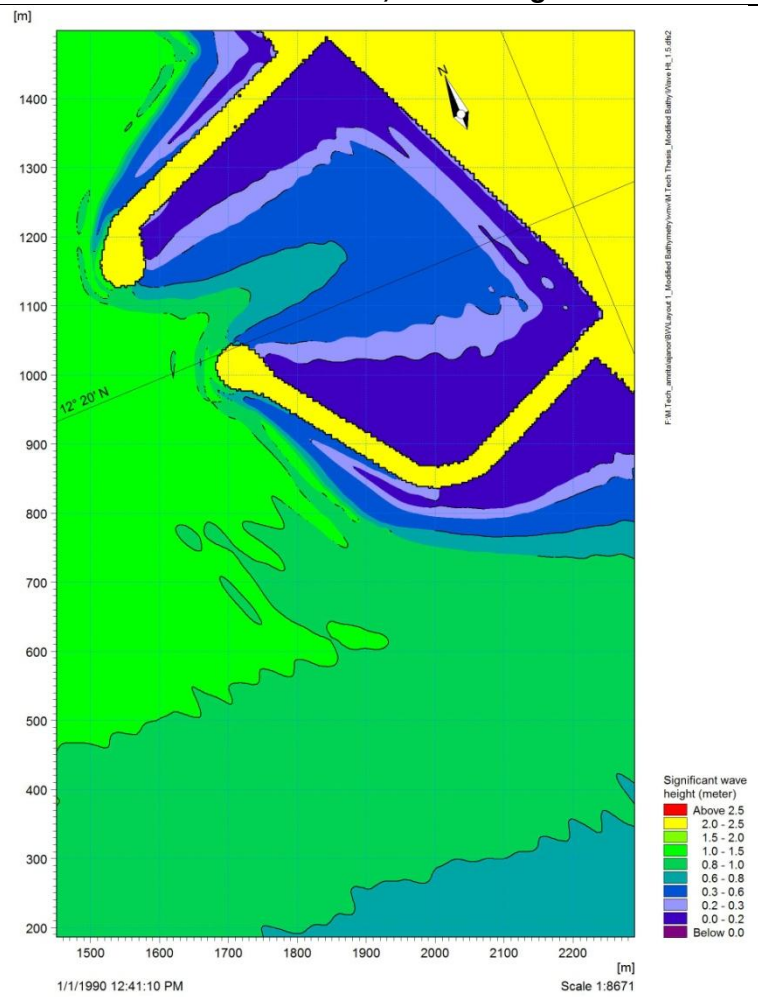


Figure 26. Zoomed in view of Figure 25

9.3 Results of Layout 1

Initially the model was operated for the incident wave height of 1.5 m from SSW direction. The Bathymetry for the simulation and surface elevation and wave distribution obtained by the model are shown in Figure 15, Figure 16 and Figure 17 & Figure 18 respectively. From these Figures and the Table 13, it could be seen that the wave heights in the Northern area are in the range of 0.30 – 1.41 m with the average of 0.58 m. An area of about 19.95% is having waves more than tranquility limit of more than 0.3 m. In the central portion and southern portion of the harbour are having wave heights within 0.3 m.

Next, the model was operated for the incident wave height of 2.0 m from SW direction. Since the bathymetry for Layout 1 is going to be the same for all the direction runs, bathymetry for SSW as representative only has been given and bathymetry for other directions has not been reproduced. Surface water elevation plot is the representative of wave propagation therefore only one sample plot has been given for SSW direction. Wave height distribution plot for SW is given in Figure 19 & Figure 20. From these Figures, and the Table 13 it could be seen that the wave heights in the Northern area are in the range of 0.30 – 1.57 m with the average of 0.69 m. An area of about 28.68% is having waves more than tranquility limit of more than 0.3 m. In the central portion and southern portion of the harbour are having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 2.5 m and direction WSW. Wave height distribution plot for WSW is given in Figure 21 & Figure 22. From these Figures, and the Table 13 it could be seen that the wave heights in the Northern area are in the range of 0.30 – 2.52 m with the average of 1.02 m. An area of about 48.04% is having waves more than tranquility limit of more than 0.3 m. In the central portion and southern portion of the harbour are having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 2.5 m and direction west. Wave height distribution plot for WSW is given in Figure 23 & Figure 24. From these Figures, and the Table 13 it could be seen that the wave heights in the Northern area are in the range of 0.30 – 0.8 m with the average of 0.4 m. An area of about 4.36% is having waves more than tranquility limit of more than 0.3 m. In the central portion and southern portion of the harbour are having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 1.5 m and direction WNW. Wave height distribution plot for WSW is given in Figure 25 & Figure 26. From these Figures, and the Table 13 it could be seen that the wave heights in the north and central portion is having the wave heights in the range of 0.30 – 1.31 m with the average of 0.50 m. An area of about 41.28% is having waves more than tranquility limit of more than 0.3 m. Southern portion of the harbour is having wave heights with in 0.3 m.

Table 13. Wave Heights in the harbour for the input wave conditions (Layout 1)

Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 3 (m)	Highest wave height in the harbour (m)
SSW	1.5	19.95	0.58	1.41
SW	2.0	28.68	0.69	1.57
WSW	2.5	48.04	1.02	2.52
West	2.5	62.21	0.84	2.51
WNW	1.5	41.28	0.50	1.13

9.4 Bathymetry, Surface Water Level and Wave Height Distribution plot for Layout 2

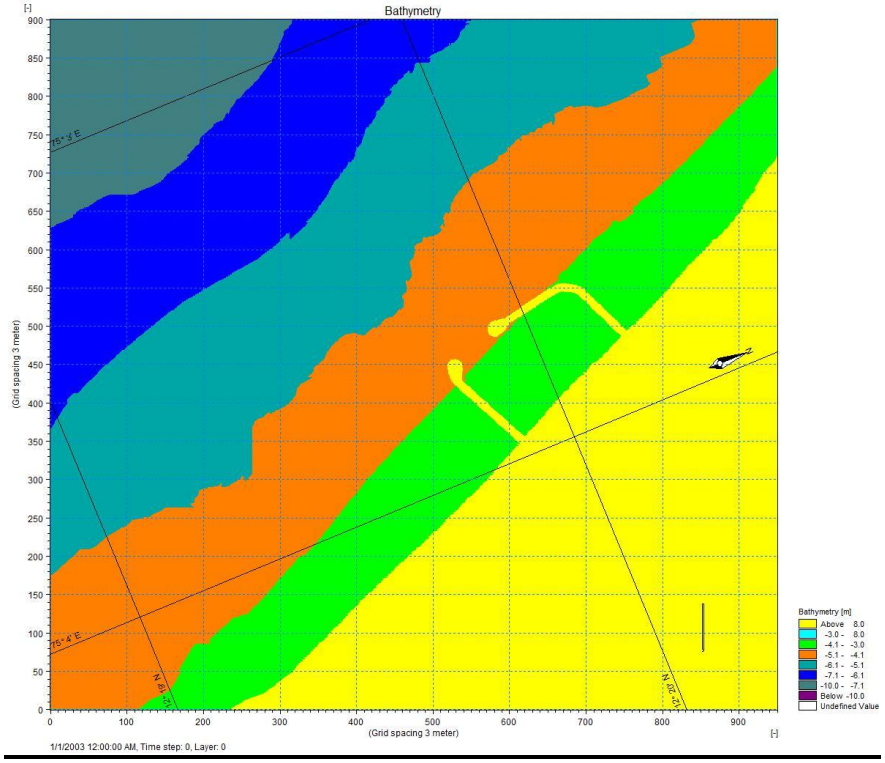


Figure 27. Sample Bathymetry Plot for Layout 2

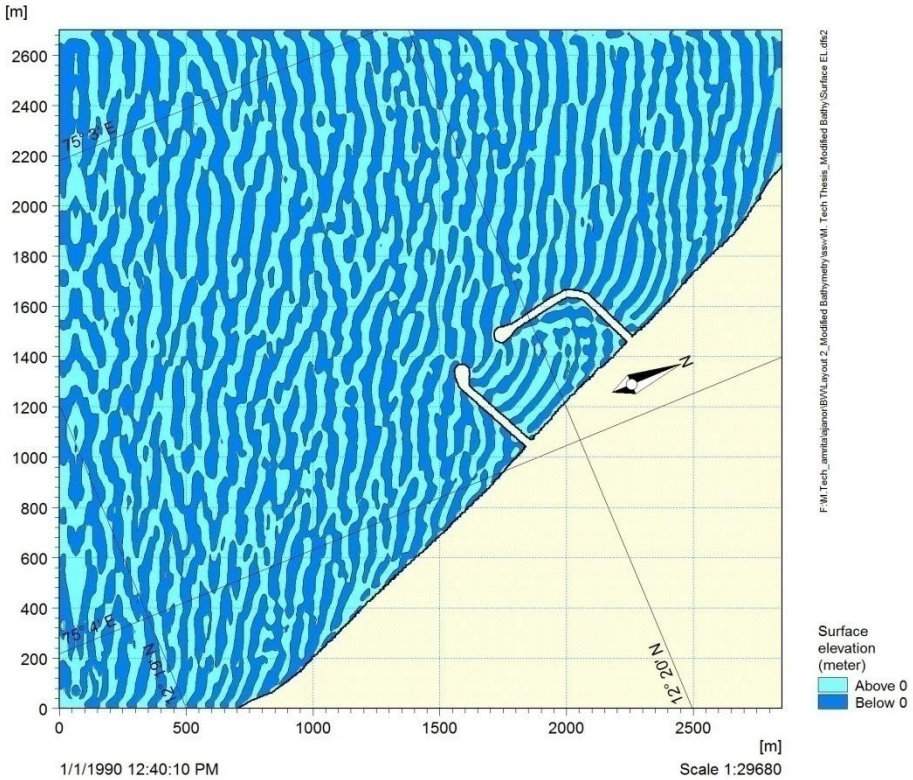


Figure 28. Sample Water Surface Elevation Plot for Layout 2

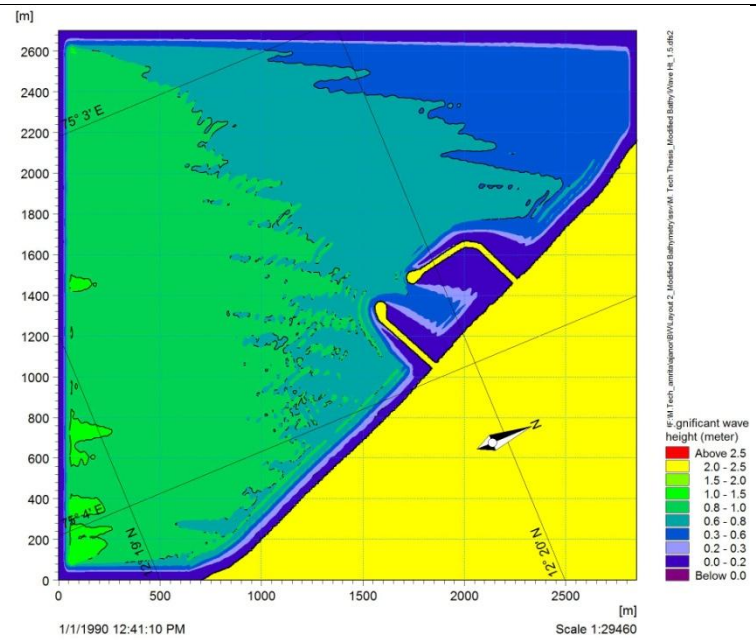


Figure 29. Wave Height Distribution Plot
Wave Direction - SSW, Wave Height - 1.5 m

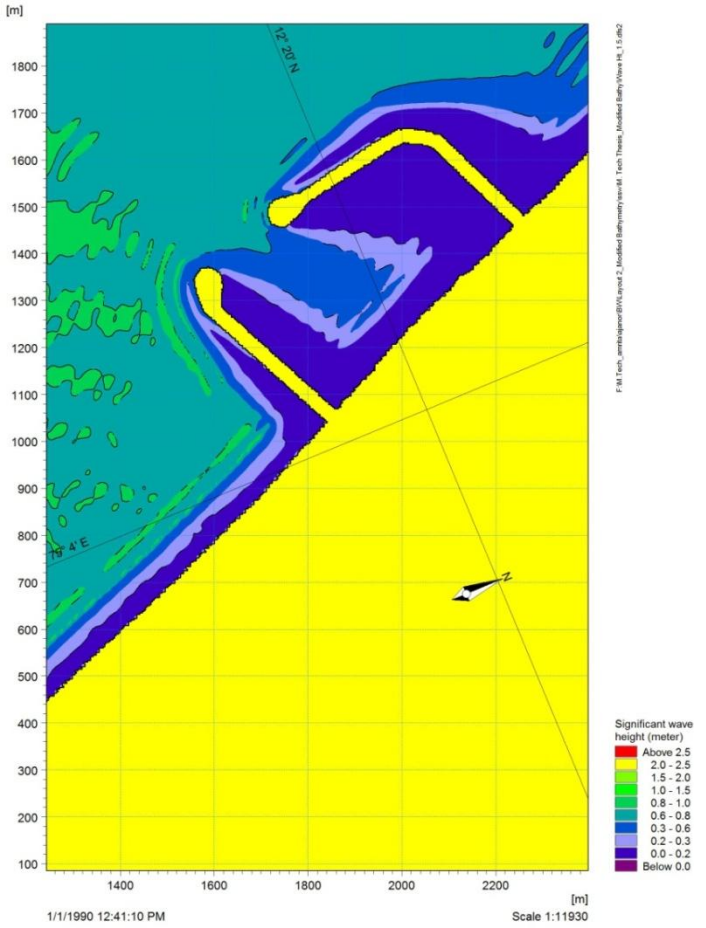


Figure 30. Zoomed in view of Figure 29

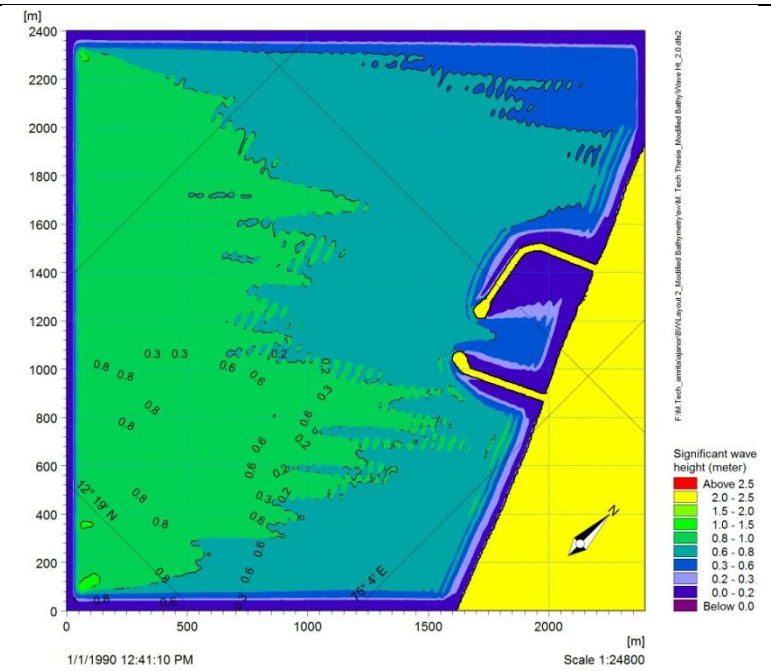


Figure 31. Wave Height Distribution Plot
Wave Direction - SW, Wave Height – 2.0 m

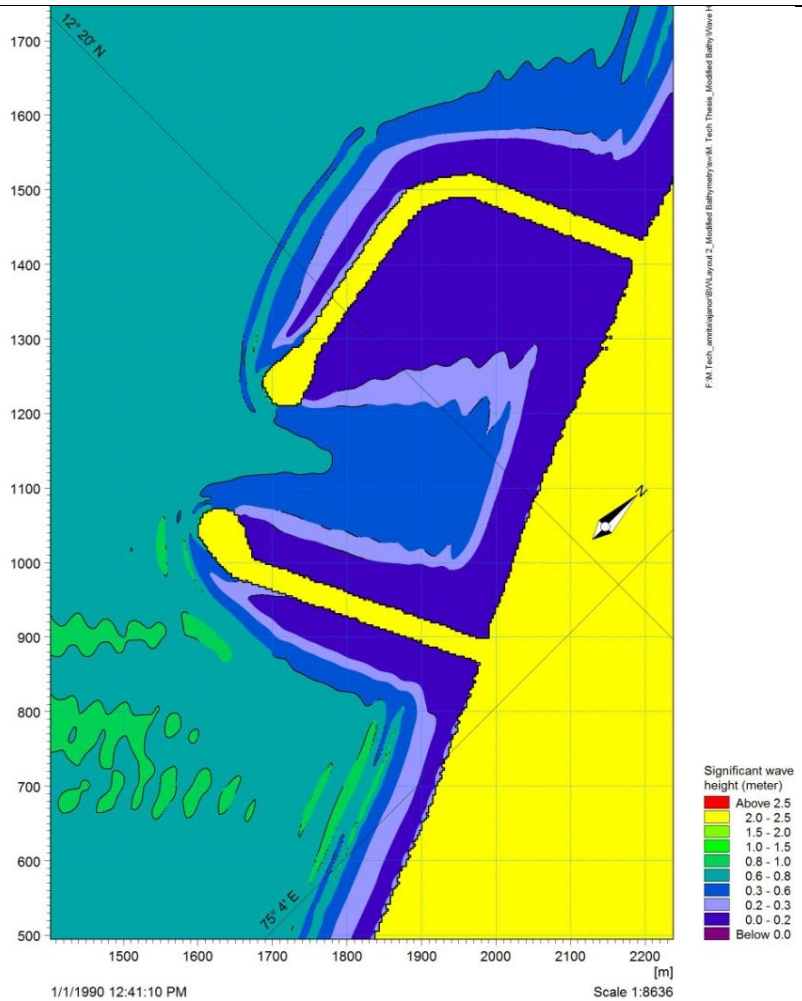


Figure 32. Zoomed in view of Figure 31

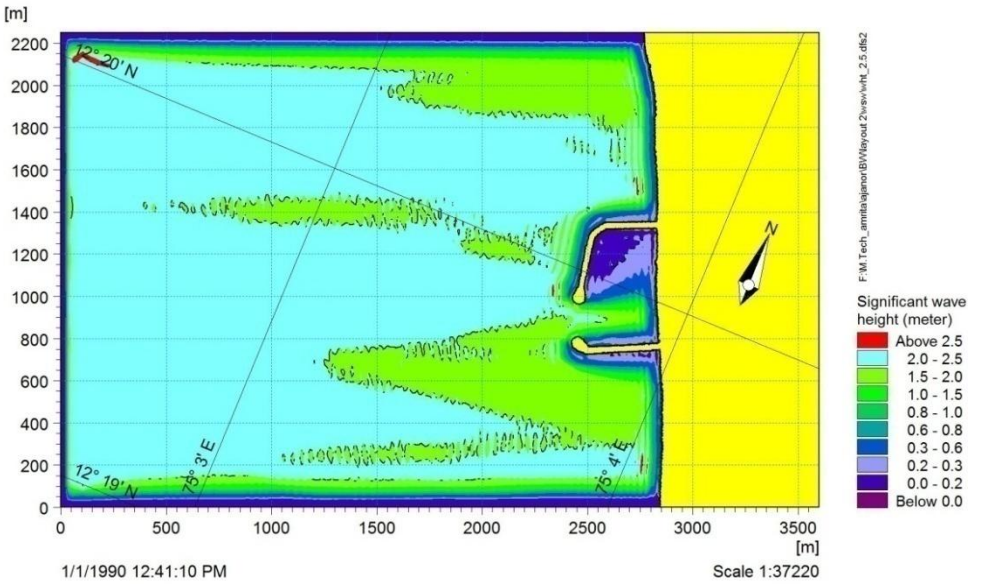


Figure 33. Wave Height Distribution Plot
Wave Direction - WSW, Wave Height - 2.5 m

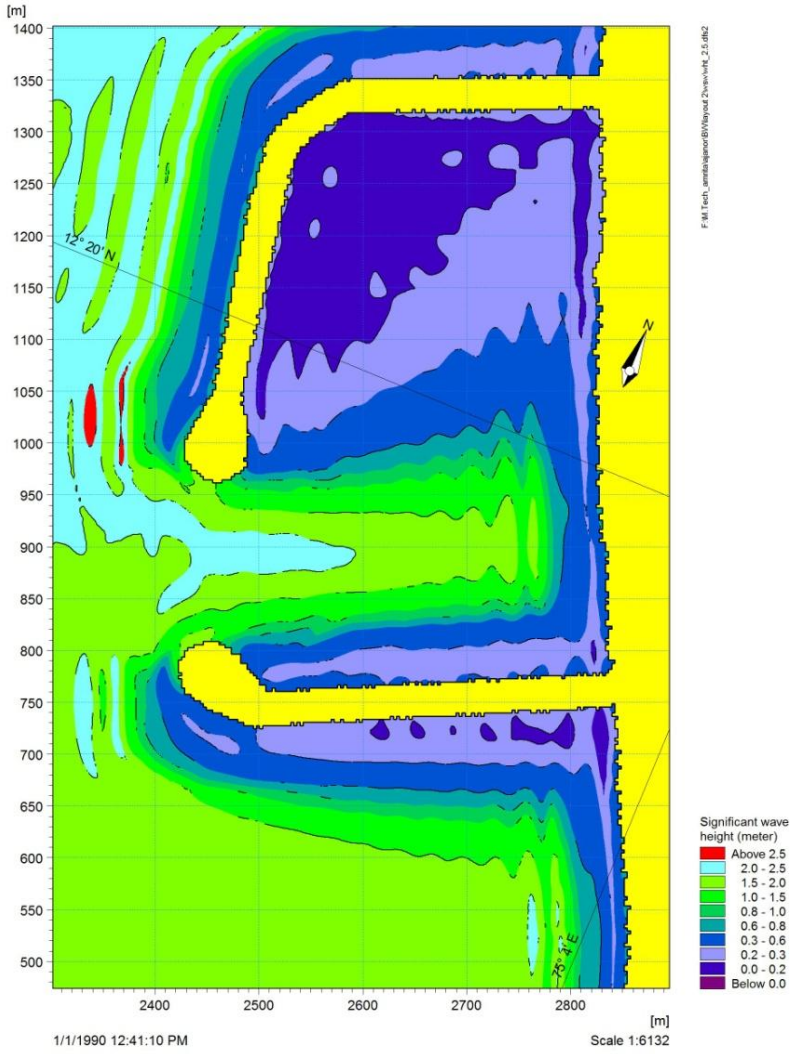


Figure 34. Zoomed in view of Figure 33

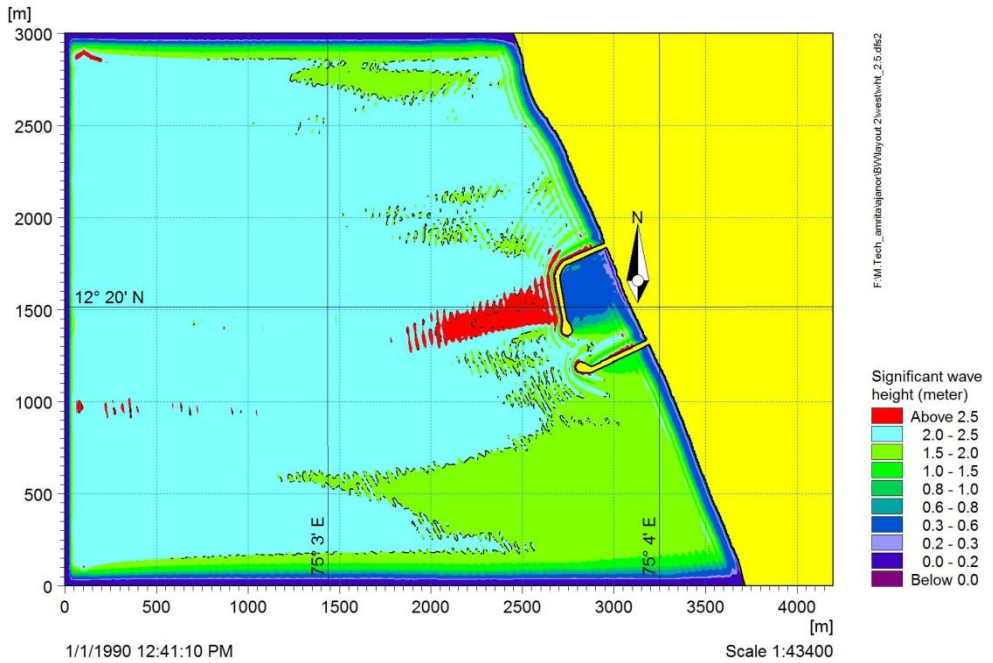


Figure 35. Wave Height Distribution Plot
Wave Direction - West, Wave Height - 2.5 m

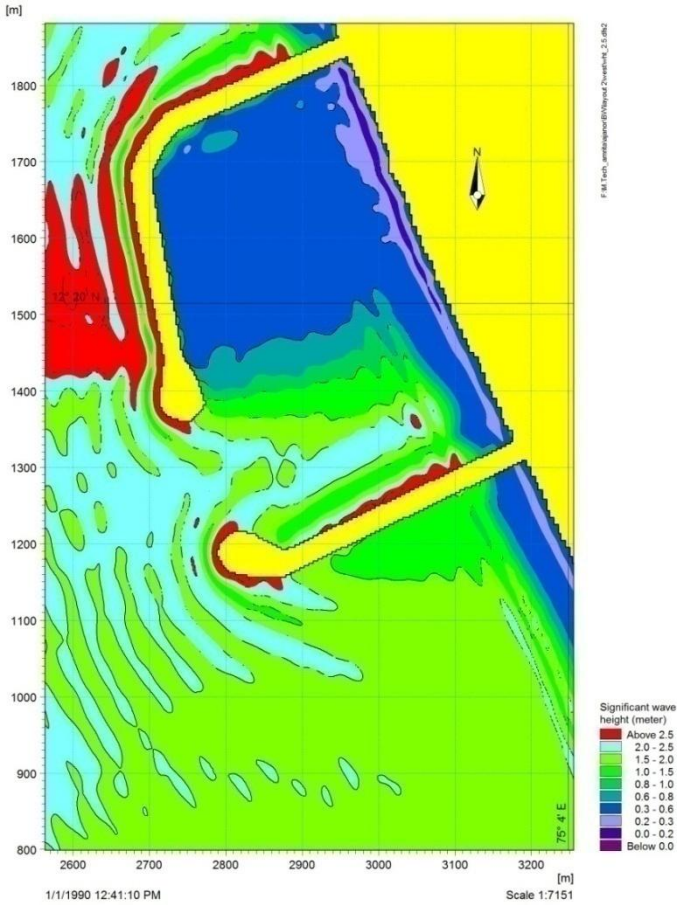


Figure 36. Zoomed in view of Figure 35

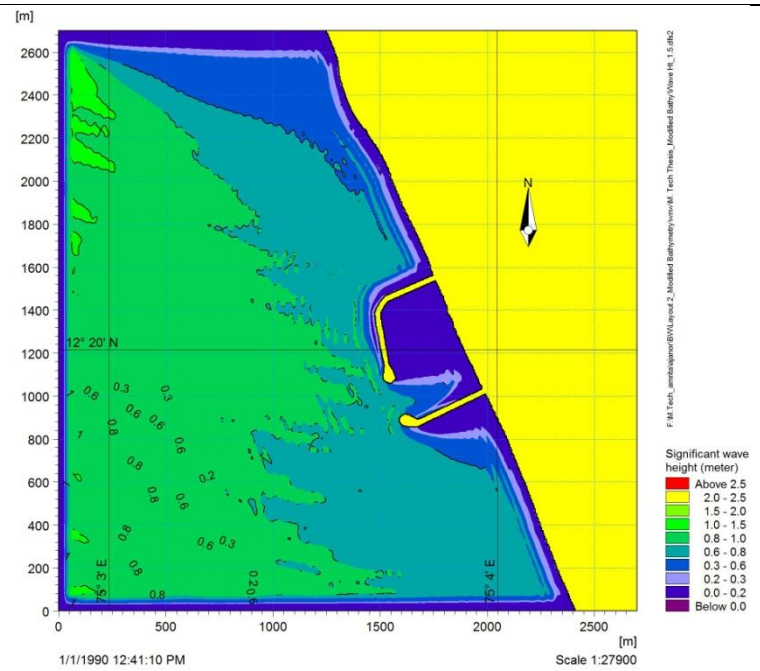


Figure 37. Wave Height Distribution Plot
Wave Direction - WNW, Wave Height - 1.5 m

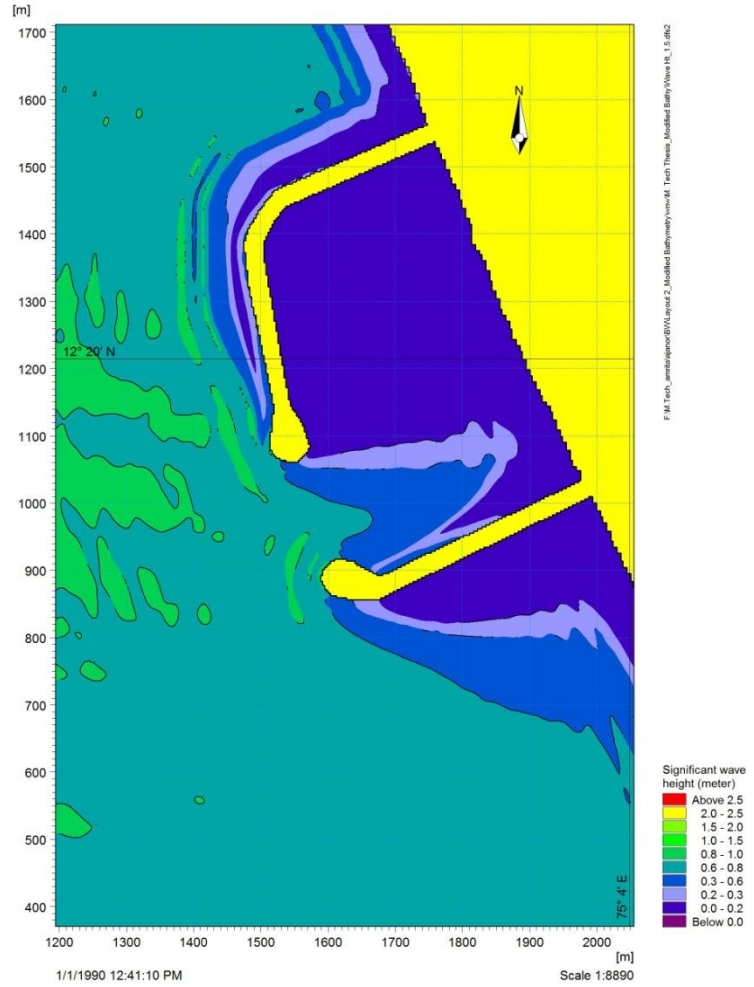


Figure 38. Zoomed in view of Figure 37

9.5 Results of Layout 2

Initially the model was operated for the incident wave height of 1.5 m from SSW direction. The Bathymetry for the simulation and surface elevation and wave distribution obtained by the model are shown in Figure 27 to Figure 30 respectively. From these Figures and the Table 14, it could be seen that the wave heights in the southern portion is in the range of 0.30 – 1.2 m with the average of 0.52 m. An area of about 38.01% is having waves more than tranquility limit of more than 0.3 m. In the central portion and northern portion of the harbour are having wave heights with in 0.3 m.

Next, the model was operated for the incident wave height of 2.0 m from SW direction. Since the bathymetry for Layout 2 is going to be the same for all the direction runs, bathymetry for SSW as representative only has been given and bathymetry for other directions has not been reproduced. Surface water elevation plot is the representative of wave propagation therefore only one sample plot has been given for SSW direction. Wave height distribution plot for SW is given in Figure 31 & Figure 32. From these Figures and the Table 14, it could be seen that the wave heights in the southern area is in the range of 0.30 – 1.52 m with the average of 0.68 m. An area of about 55.31% is having waves more than tranquility limit of more than 0.3 m. Less than half of the harbour is having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 2.5 m and direction WSW. Wave height distribution plot for WSW is given in Figure 33 & Figure 34. From these Figures and the Table 14, it could be seen that the wave heights in the Northern area are in the range of 0.30 – 2.52 m with the average of 1.02 m. An area of about 48.04% is having waves more than tranquility limit of more than 0.3 m. In the central portion and southern portion of the harbour are having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 2.5 m and direction West. Wave height distribution plot for WSW is given in Figure 35 & Figure 36. From these Figures and the Table 14, it could be seen that the wave heights in the southern area are in the range of 0.30 – 0.8 m with the average of 0.4 m. An area of about 4.36% is having waves more than tranquility limit of more than 0.3 m. In the central portion and Northern portion of the harbour are having wave heights with in 0.3 m.

Then, the model was operated for the incident wave height of 1.5 m and direction WNW. Wave height distribution plot for WNW is given in Figure 37 & Figure 38. From these Figures and Table 14, it could be seen that the wave heights in the central and southern portion is having the wave heights in the range of 0.30 – 1.31 m with the average of 0.50 m. An area of about 41.28% is having waves more than tranquility limit of more than 0.3 m. Northern portion of the harbour is having wave heights with in 0.3 m.

Table 14. Wave Heights in the harbour for the input wave conditions (Layout 2)

Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 3 (m)	Highest wave height in the harbour (m)
SSW	1.5	38.01	0.52	1.20
SW	2.0	55.31	0.68	1.52
WSW	2.5	51.64	0.98	2.28
West	2.5	92.69	0.93	3.99
WNW	1.5	23.41	0.58	1.13

9.6 Bathymetry, Surface Water Level and Wave Height Distribution plot for Layout 3

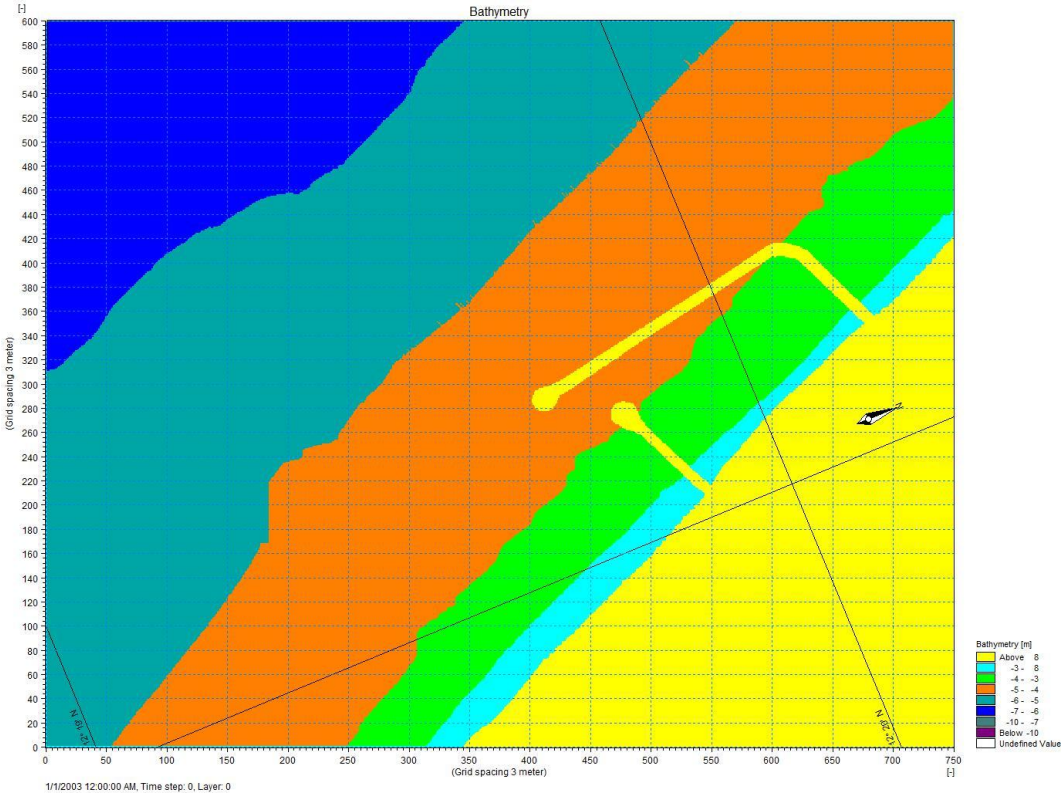


Figure 39. Sample Bathymetry for Layout 3

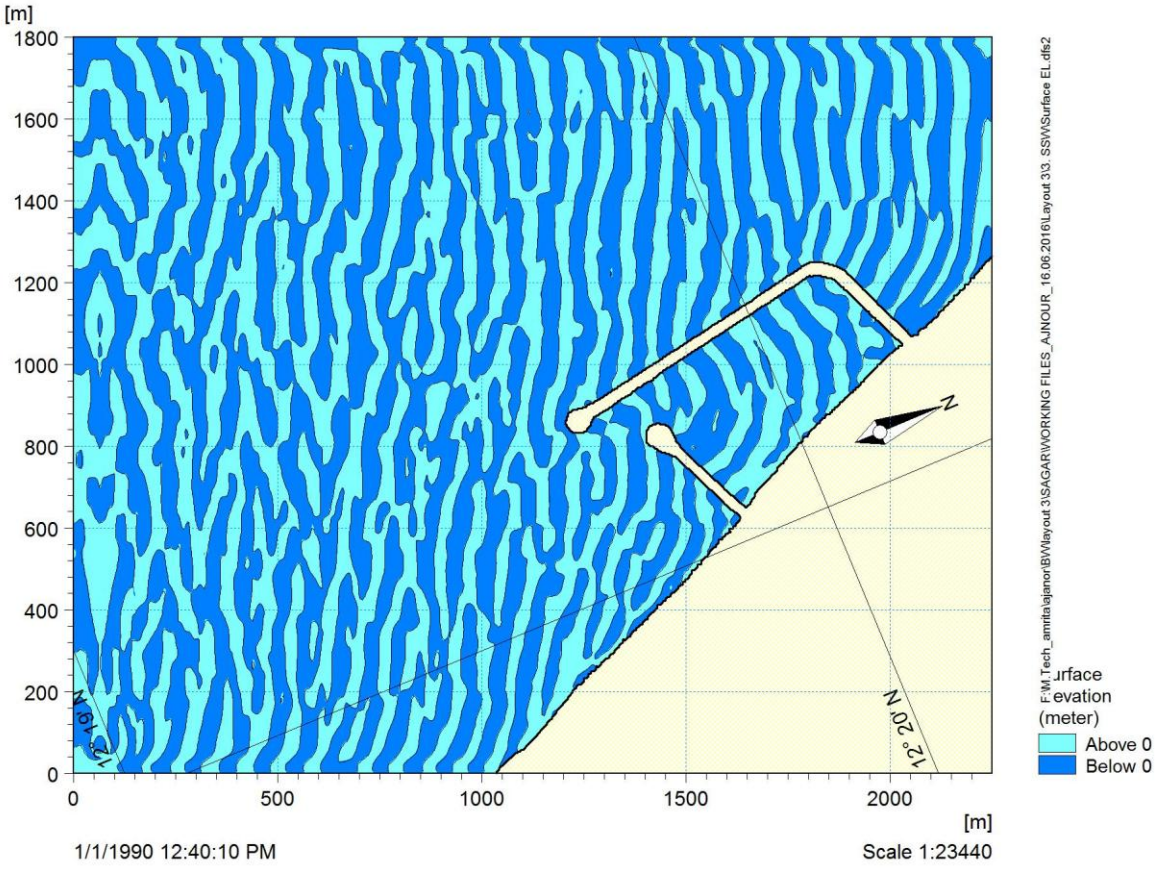


Figure 40. Sample Surface Water Distribution Plot for Layout 3

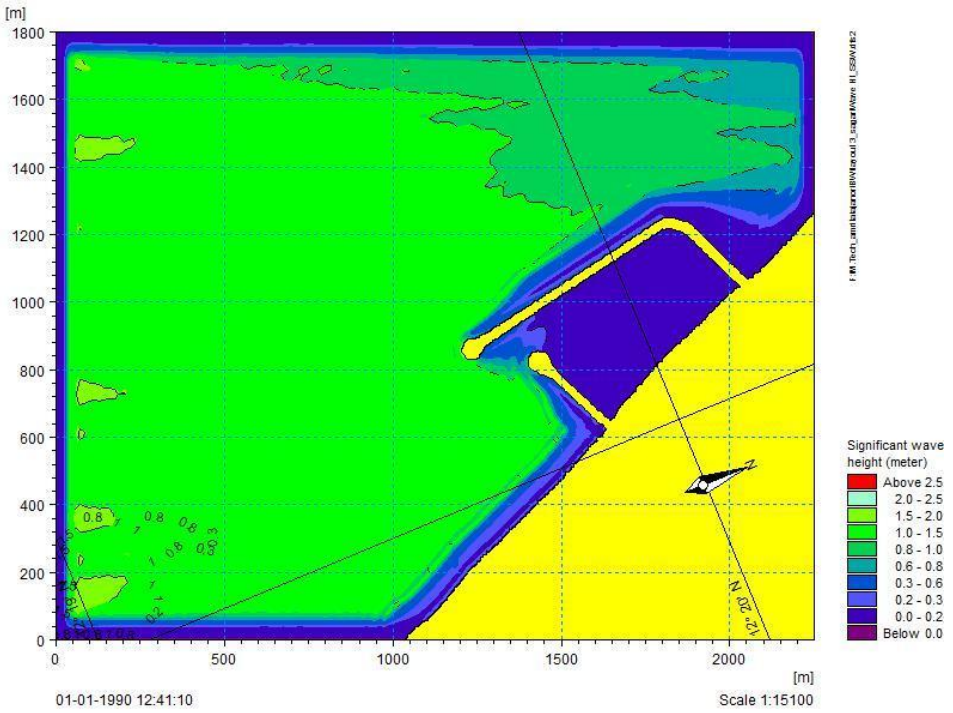


Figure 41. Wave Height Distribution Plot
Wave Direction - SSW, Wave Height - 1.5 m

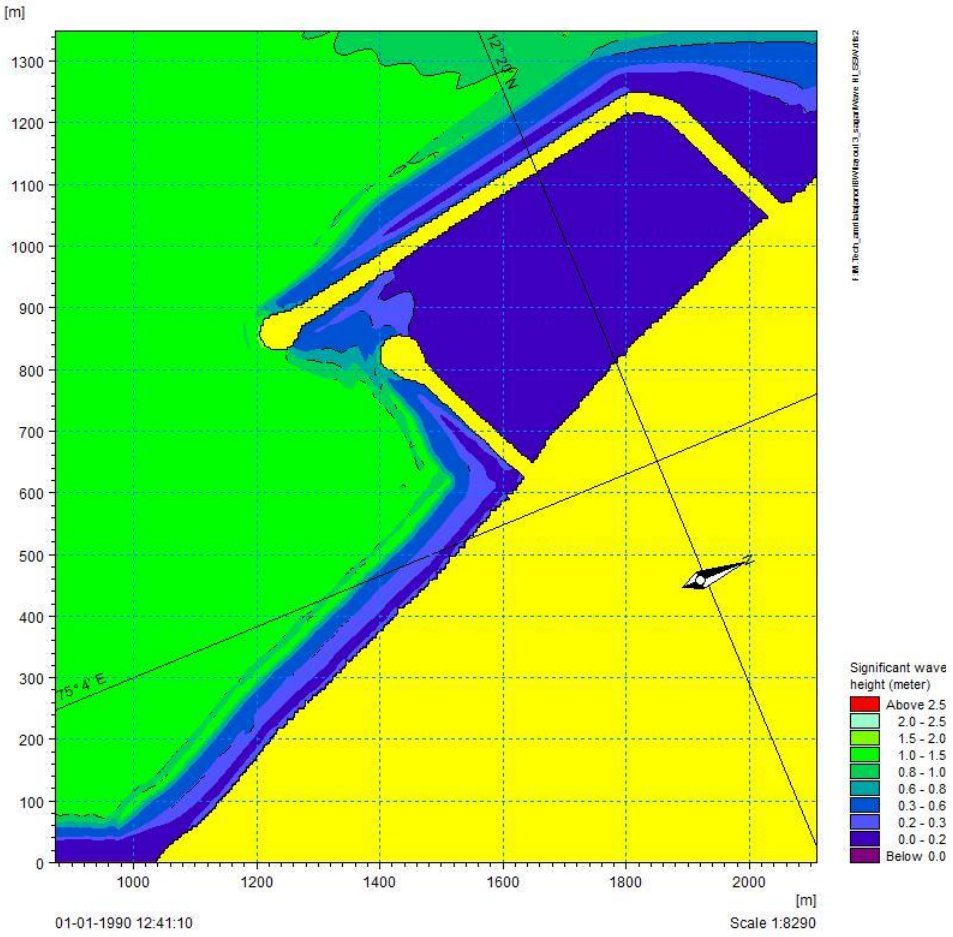


Figure 42. Zoomed in view of Figure 41

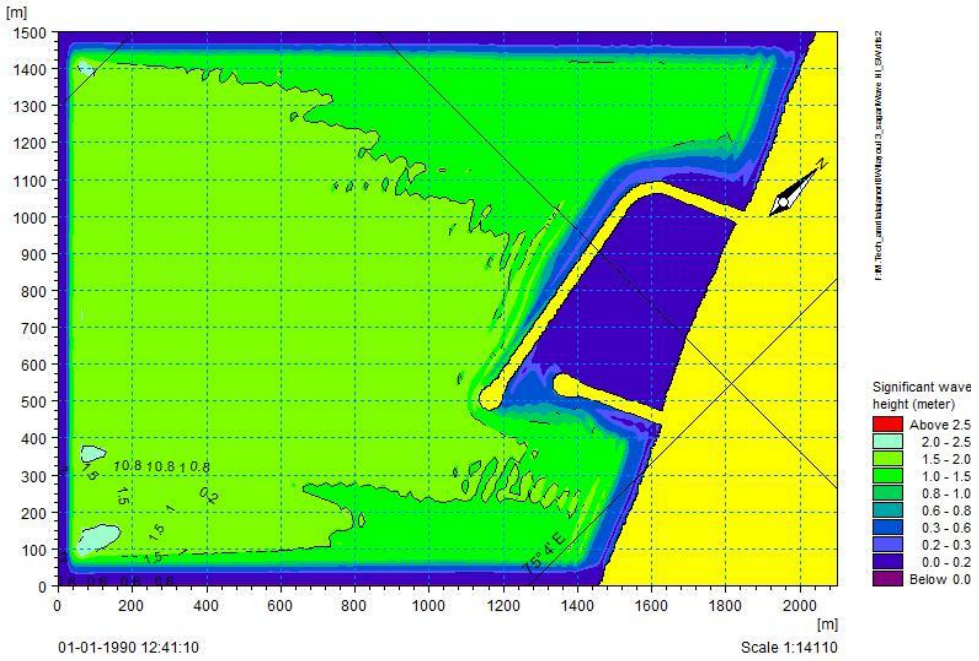


Figure 43. Wave Height Distribution Plot
Wave Direction - SW, Wave Height - 2.0 m

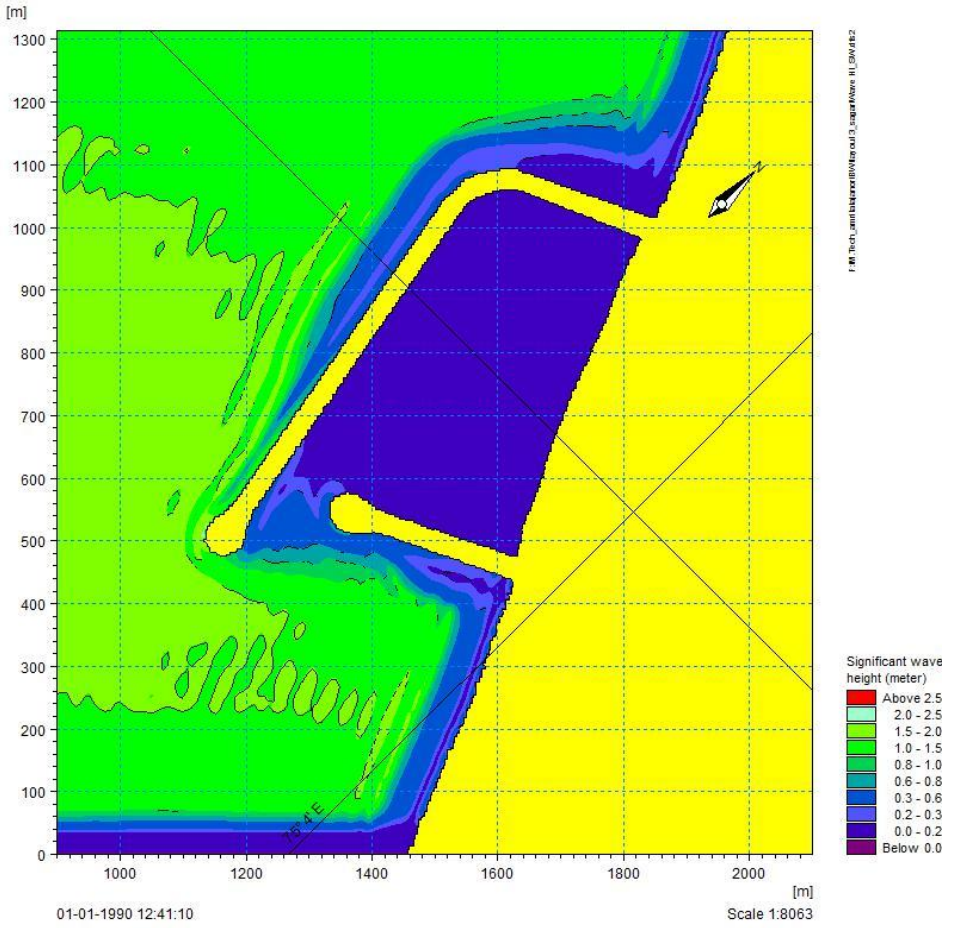


Figure 44. Zoomed in view of Figure 43

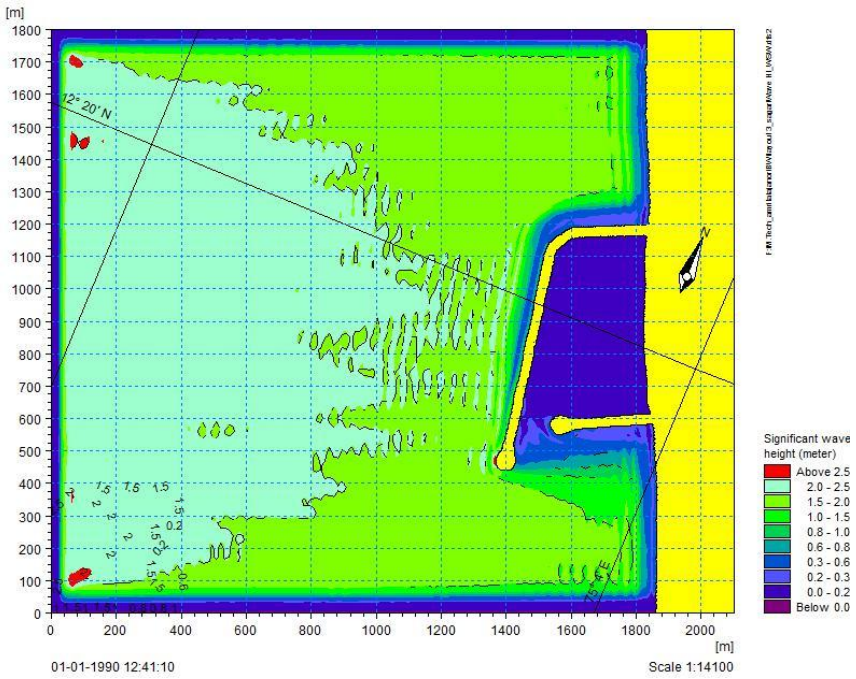


Figure 45. Wave Height Distribution Plot
Wave Direction - WSW, Wave Height - 2.5 m



Figure 46. Zoomed in view of Figure 45

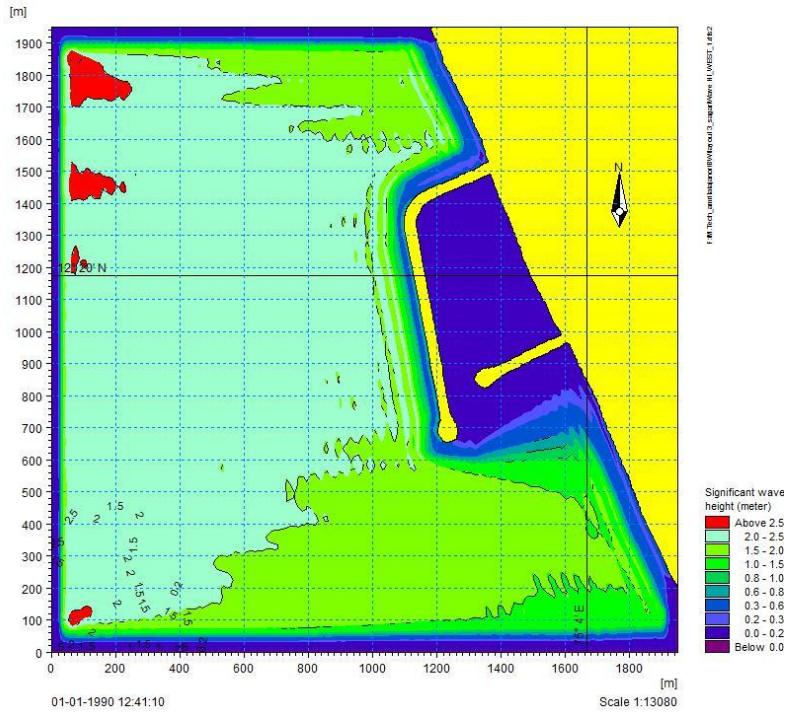


Figure 47. Wave Height Distribution Plot
Wave Direction - West, Wave Height - 2.5 m

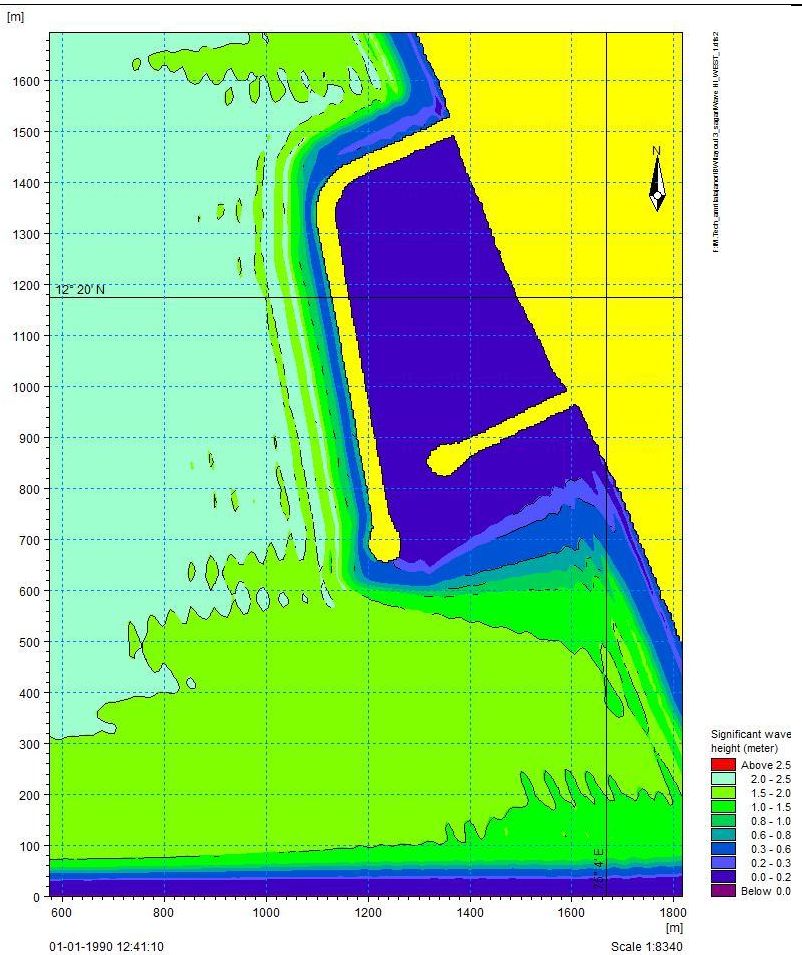


Figure 48. Zoomed in view of Figure 47

9.7 Results of Layout 3

Initially the model was operated for the incident wave height of 1.5 m from SSW direction. The Bathymetry for the simulation and surface elevation and wave distribution obtained by the model are shown in Figure 39, Figure 40, Figure 41 & Figure 42 respectively. From these Figures and the Table 15 it could be seen that the wave heights in the southern portion is in the range of 0.30 – 0.55 m with the average of 0.35 m. An area of only 1.09% is having waves more than tranquility limit of more than 0.3 m. It can be stated that the whole harbour is tranquil.

Next, the model was operated for the incident wave height of 2.0 m from SW direction. Since the bathymetry for Layout 3 is going to be the same for all the direction runs, bathymetry for SSW as representative only has been given and bathymetry for other directions has not been reproduced. Surface water elevation plot is the representative of wave propagation therefore only one sample plot has been given for SSW direction. Wave height distribution plot for SW is given in Figure 43 & Figure 44. From these Figures and the Table 15 could be seen that the wave heights in the southern area is in the range of 0.30 – 61 m with the average of 0.37 m. An area of about less than 1% is having waves more than tranquility limit of more than 0.3 m. All most the whole harbour is tranquil.

Then, the model was operated for the incident wave height of 2.5 m and direction WSW. Wave height distribution plot for WSW is given in Figure 45 & Figure 46. From these Figures and the Table 15 it could be seen that the wave heights in the Northern area are in the range of 0.30 – 0.39 m with the average of 0.32 m. An area of about less than 1% is having waves more than tranquility limit of more than 0.3 m. All most the whole harbour is tranquil.

Then, the model was operated for the incident wave height of 2.5 m and direction West. Wave height distribution plot for WSW is given in Figure 47 & Figure 48. From these Figures and the Table 15 it could be seen that the wave heights at the entrance are in the range of 0.30 – 0.39 m with the average of 0.32 m. An area of about less than 1% is having waves more than tranquility limit of more than 0.3 m. All most the whole harbour is tranquil.

Table 15 : Wave Heights in the harbour for the input wave conditions (Layout 3)

Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 3 (m)	Highest wave height in the harbour (m)
SSW	1.5	1.09	0.35	0.55
SW	2.0	0.10	0.31	0.38
WSW	2.5	0.08	0.37	0.61
West	2.5	0.08	0.32	0.39
WNW	*	*	*	*

** Since the harbour is tranquil for other critical wave directions, it will remain tranquil for this WNW direction also. Due to this reason WNW wave direction was not studied for this layout.*

9.8 Bathymetry, Surface Water Level and Wave Height Distribution plot for Layout 4

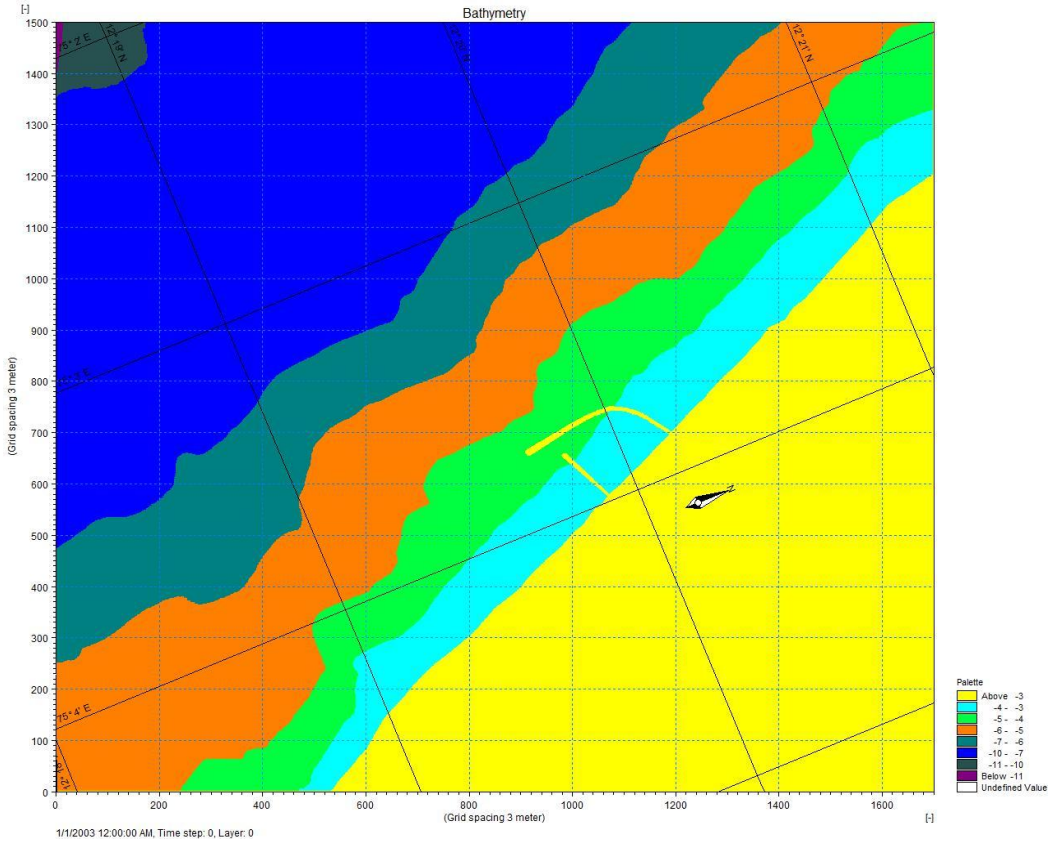


Figure 49. Sample Bathymetry Plot for Layout 4

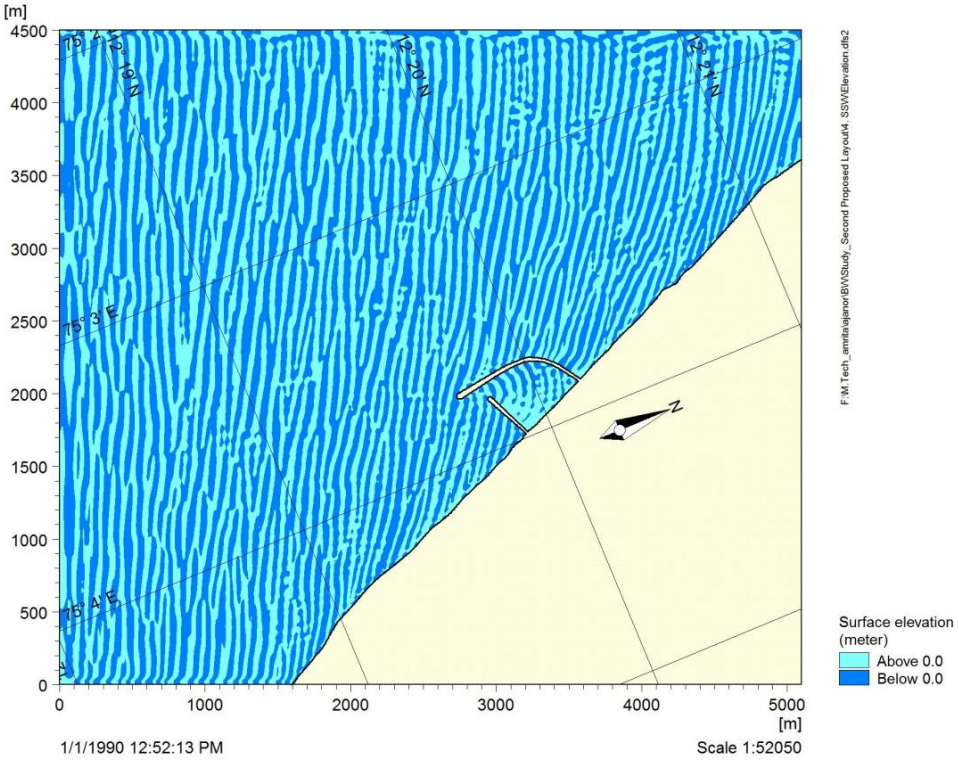


Figure 50. Sample Surface Water Distribution Plot for Layout 4

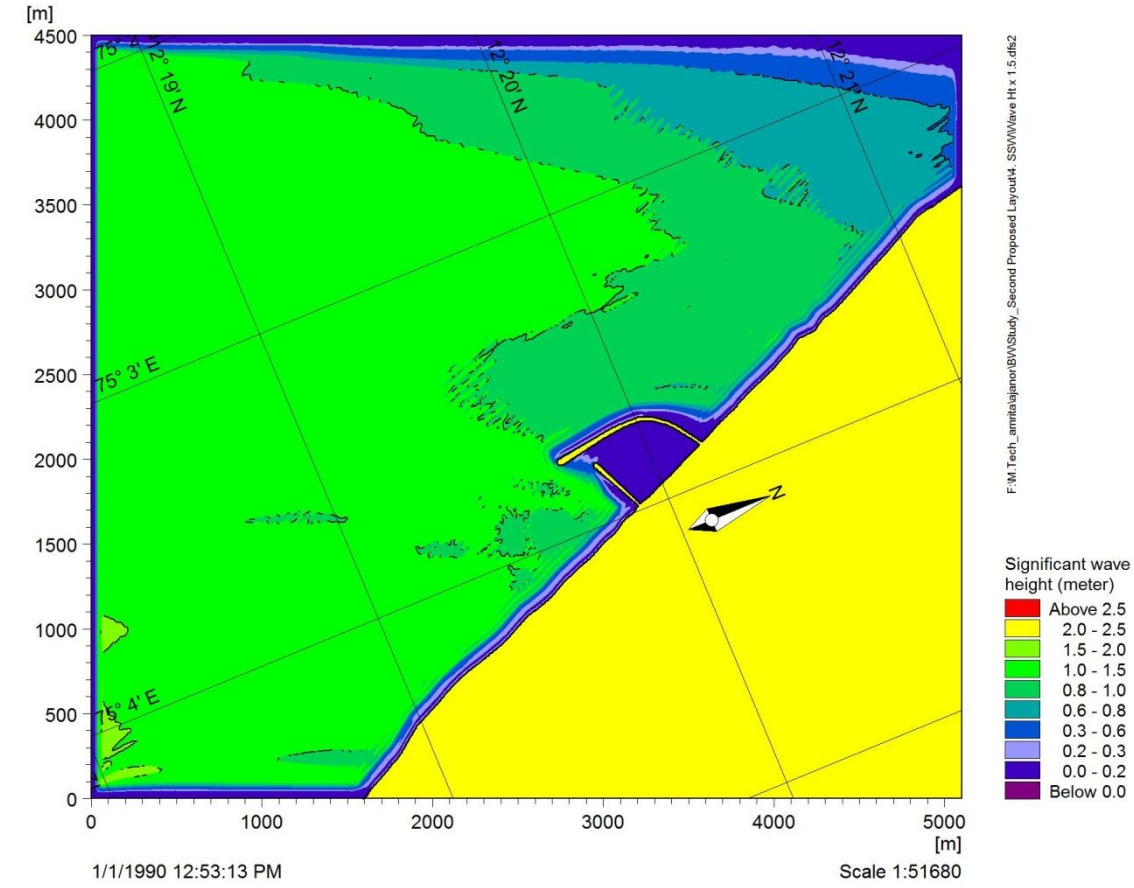


Figure 51. Wave Height Distribution Plot
Wave Direction - SSW, Wave Height - 1.5 m

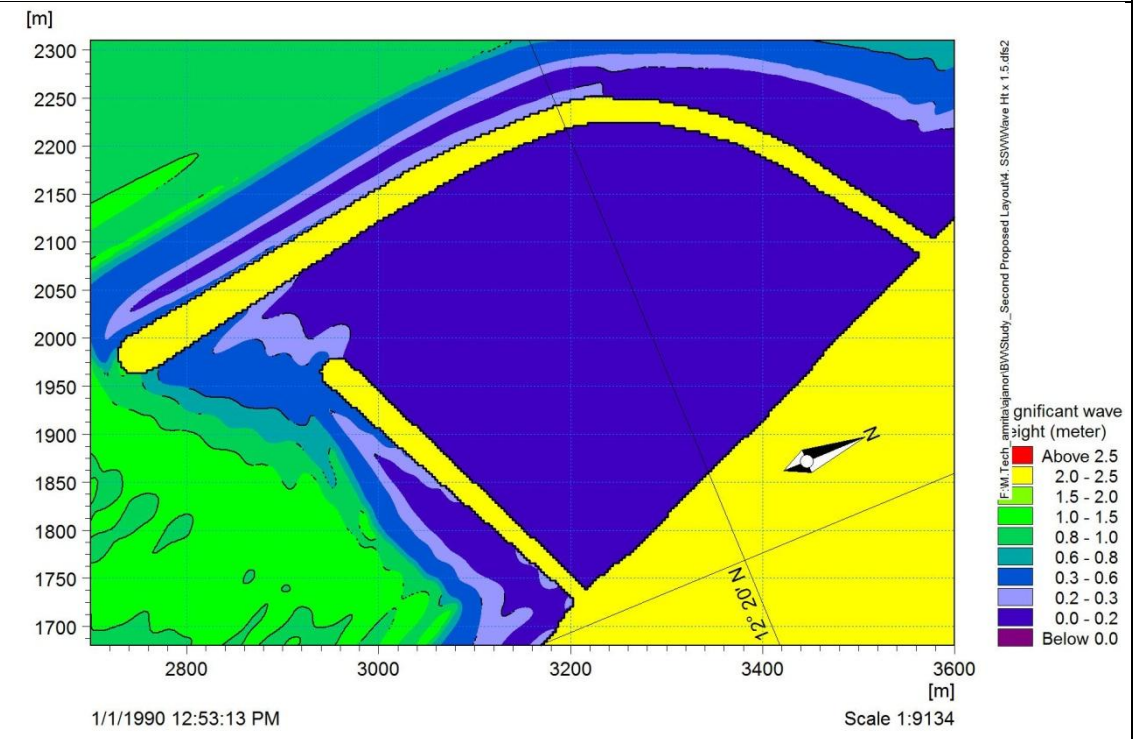


Figure 52. Zoomed in view of Figure 51

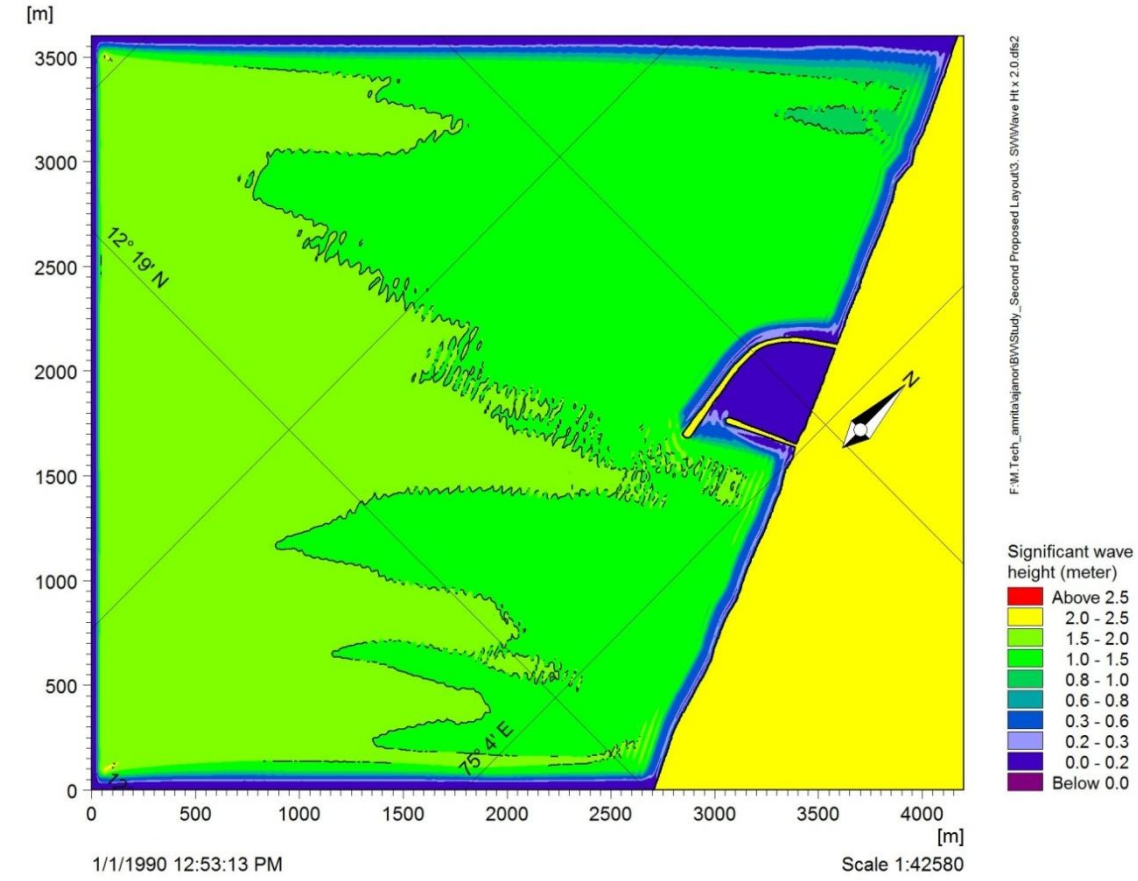


Figure 53. Wave Height Distribution Plot
Wave Direction - SW, Wave Height - 2.0 m

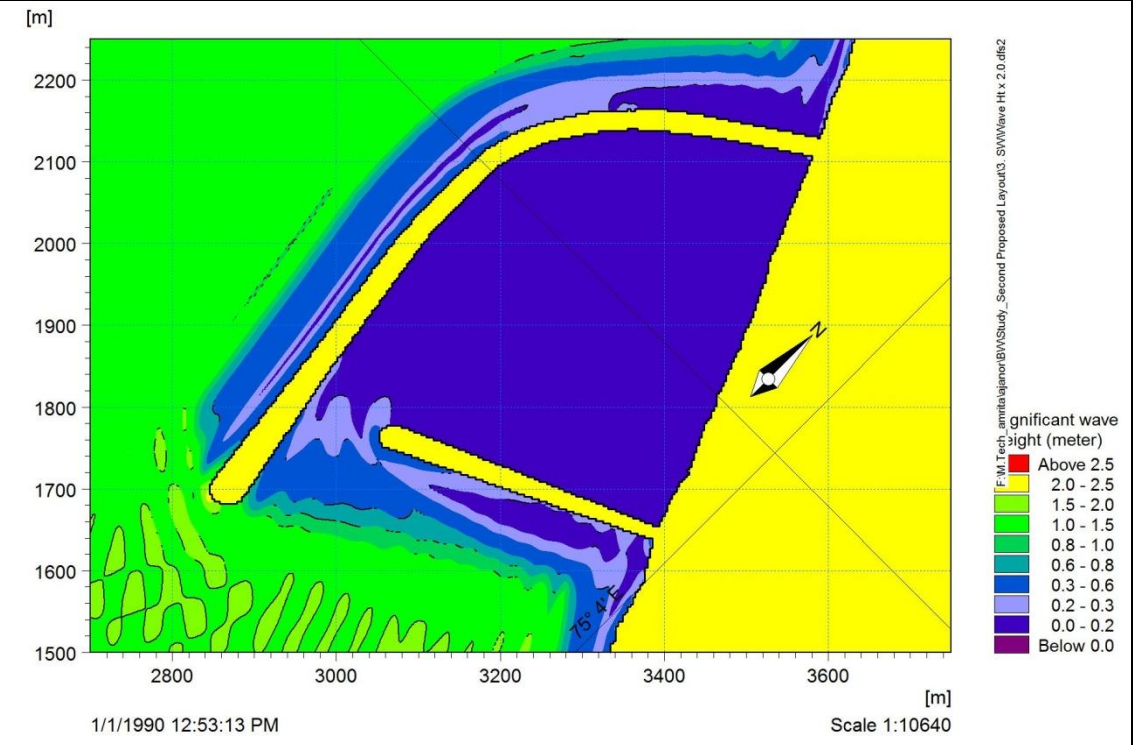


Figure 54. Zoomed in view of Figure 53

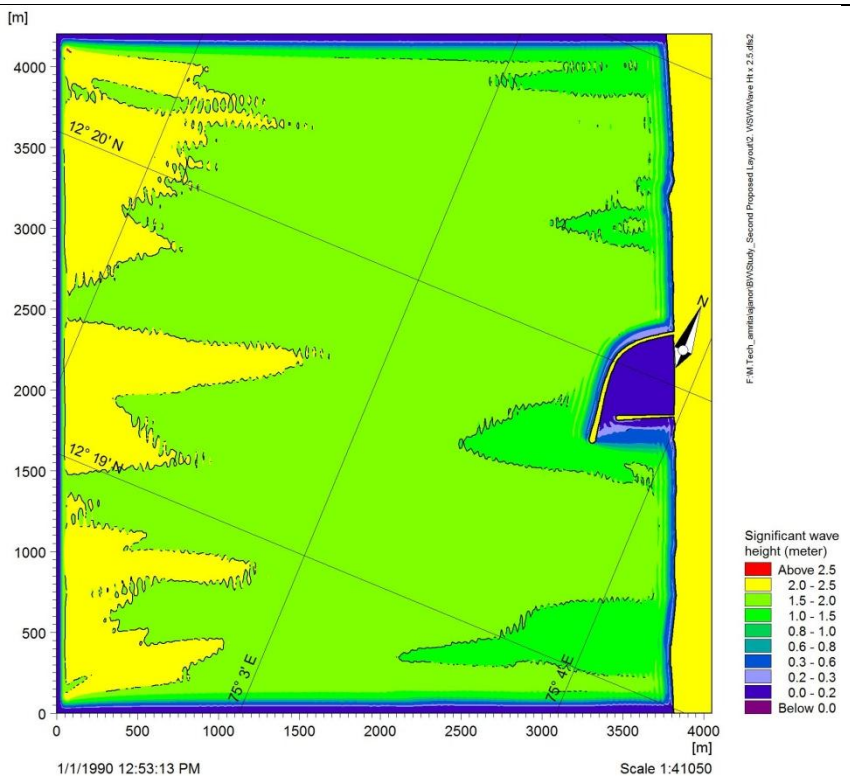


Figure 55. Wave Height Distribution Plot
Wave Direction - WSW, Wave Height - 2.5 m

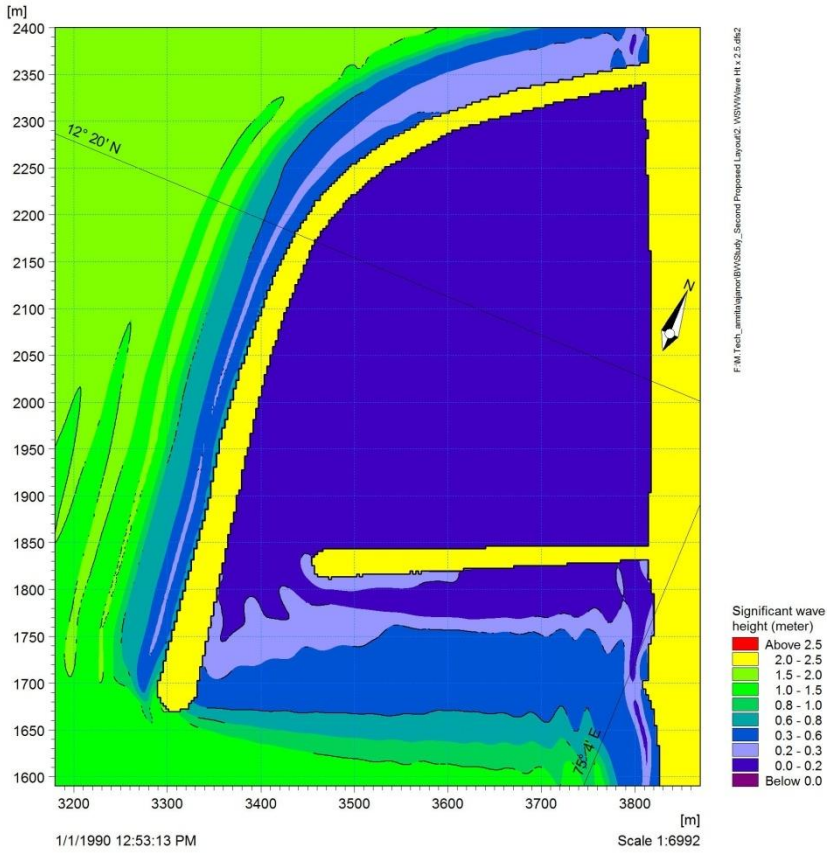


Figure 56. Zoomed in view of Figure 55

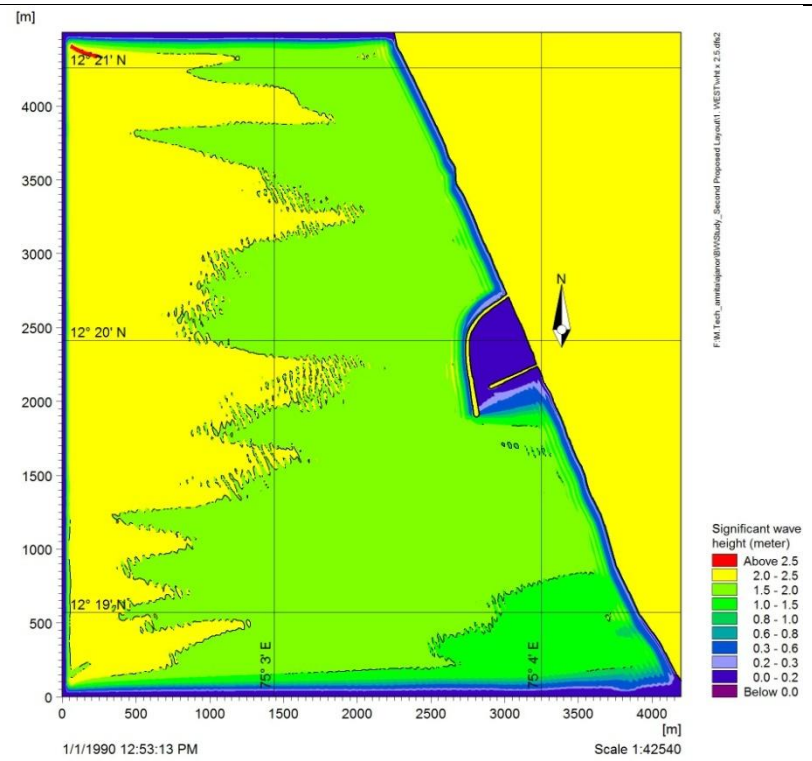


Figure 57. Wave Height Distribution Plot
Wave Direction - West, Wave Height - 2.5 m

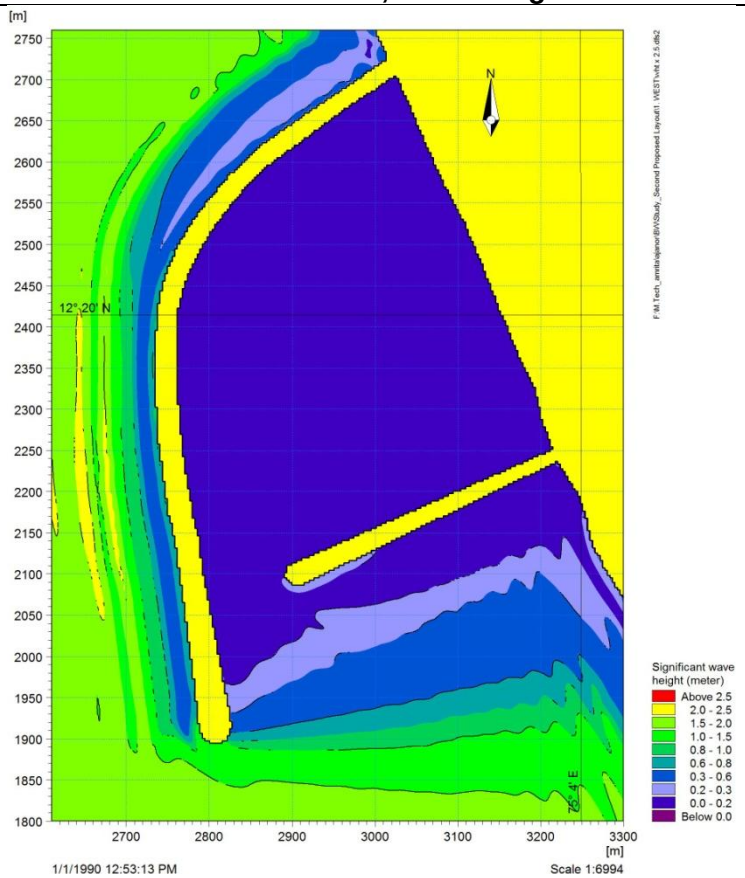


Figure 58. Zoomed in view of Figure 57

9.9 Results of Layout 4

Initially the model was operated for the incident wave height of 1.5 m from SSW direction. The Bathymetry for the simulation, surface elevation and wave distribution obtained by the model are shown in Figure 49, Figure 50, Figure 51 & Figure 52 respectively. From these Figures and the Table 10, it could be seen that the wave heights inside the entire harbour is in the range of 0.09 – 0.37 m with the average of 0.06 m. An area of only 0.04% is having waves more than tranquility limit of more than 0.3 m. It can be stated that the whole harbour is tranquil.

Next, the model was operated for the incident wave height of 2.0 m from SW direction. Since the bathymetry for layout-4 is going to be the same for all the direction runs, bathymetry for SSW as representative only has been given and bathymetry for other directions has not been reproduced. Surface water elevation plot is the representative of wave propagation therefore only one sample plot has been given for SSW direction. Wave height distribution plot for SW is given in Figure 53 & Figure 54. From these Figures and the Table 10, it could be seen that the wave heights inside the entire harbour area is in the range of 0.10-0.40 m with the average of 0.07 m. An area of about 0.12% is having waves more than tranquility limit of more than 0.3 m. All most the whole harbour is tranquil.

Then, the model was operated for the incident wave height of 2.5 m and direction WSW. Wave height distribution plot for WSW is given in Figure 55 & Figure 56. From these Figures and the Table 10, it could be seen that the wave heights in the entire harbour area are in the range of 0.06-0.28 m with the average of 0.09 m. No area inside the harbour is having waves more than tranquility limit of more than 0.3 m, thus, harbour is tranquil.

Then, the model was operated for the incident wave height of 2.5 m and direction west. Wave height distribution plot for West is given in Figure 57 & Figure 58. From these Figures and the Table 10, it could be seen that the wave heights in the entire are in the range of 0.07-0.25 m with the average of 0.09 m. Therefore, it can be stated that the entire harbour area is tranquil as the waves more than tranquility limit of more than 0.3 m are not observed.

Table 16 : Wave Heights in the harbour for the input wave conditions (Layout 4)

Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 3 (m)	Highest wave height in the harbour (m)
SSW	1.5	0.04	0.06	0.37
SW	2.0	0.12	0.07	0.40
WSW	2.5	NIL	0.09	0.28
West	2.5	NIL	0.09	0.25
WNW	*	*	*	*

**Since the harbour is tranquil for other critical wave directions, it will remain tranquil for this WNW direction also. Due to this reason WNW wave direction was also not studied for this layout.*

Gist of wave heights inside the harbour, height wave height average wave height in the higher wave height area zone for all the three layouts is given in the **Table 17** below.

Table 17 : Wave Height, Average wave Height and Maximum wave heights of all the three layouts

Layout	Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 4 (m)	Highest wave height in the harbour (m)	Remarks
Column No1	2	3	4	5	6	7
Layout 1	SSW	1.5	19.95	0.58	1.41	
	SW	2.0	28.68	0.69	1.57	
	WSW	2.5	48.04	1.02	2.52	
	West	2.5	62.21	0.84	2.51	
	WNW	1.5	41.28	0.50	1.13	
Layout 2	SSW	1.50	38.01	0.52	1.20	
	SW	2.0	55.31	0.68	1.52	
	WSW	2.5	51.64	0.98	2.28	
	West	2.5	92.69	0.93	3.99	
	WNW	1.5	23.41	0.58	1.13	
Layout 3	SSW	1.5	1.09	0.35	0.55	
	SW	2.0	0.10	0.31	0.38	
	WSW	2.5	0.08	0.37	0.61	
	West	2.5	0.08	0.32	0.39	

Layout	Wave Direction	Wave Height (m)	Area (%) having more than 0.3 m wave height	Average wave height in the area given in col. 4 (m)	Highest wave height in the harbour (m)	Remarks
	WNW	-	-	-	-	
Layout 4	SSW	1.5	0.04	0.06	0.37	
	SW	2.0	0.12	0.07	0.40	
	WSW	2.5	0.0	0.09	0.28	
	West	2.5	0.0	0.09	0.25	
	WNW	*	*	*	*	

**Since the harbour is tranquil for other critical wave directions, it will remain tranquil for this WNW direction also. Due to this reason WNW wave direction was also not studied for this layout.*

10. DISCUSSION OF RESULTS

Wave tranquility study of all the four proposed layouts have indicated that Layout 1 will have 164 days as non operational days in a year when waves are likely to exceed 0.3 m. Similarly Layout 2 is also having 157 days as non operational days. Layout 3 & 4 shall remain operational from wave tranquility point of view throughout the year. Project authority may decide the feasibility among the Layout 3 and Layout 4 based on the economy. However vessels may face some difficulty while entering to the harbour as they have to sail for a short distance along the waves i.e. broadside waves in both cases. Littoral drift studies carried out at CWPRS (T.R. No. 5357 of February 2016) have also indicated that southward drift is predominant.

Table 18 : Number of Safe operational Days in a year

Layout	Layout--1	Layout-2	Layout-3	Layout-4
Number of operational days	201 days in the southern harbour	208 days in the northern harbour	365 days in the harbour	365 days in the harbour

11. CONCLUSIONS

- The percentage occurrence of wave distribution Table 8 at 10m depth near Ajanur for January to December shows that , the predominant wave directions are SSW, SW , WSW , West , and WNW with the percentage occurrence of 8.55, 5.35, 8.56, 23.72 and 16.78 respectively. The maximum wave height of 3.0 m from West direction is observed.
- The input wave conditions for the wave tranquility studies are derived as follows for input to the MIKE21BW model for study of with Layout 1, Layout 2, Layout 3 and Layout 4.

Incident Wave Direction	Incident Wave Height
SSW	1.5
SW	2.0
WSW	2.5
WEST	2.5
WNW	1.5

- The wave tranquility studies with Layout 1 indicated that the berthing operations have to be planned in the southern area. The wave heights from WSW, West and WNW are creating more disturbances in the entrance area. Safe berthing operation is possible for about 201 days in a year.
- The wave tranquility studies with Layout 2 indicated that the berthing operations have to be planned in the northern area. Safe berthing operation is possible for about 208 days in a year
- With Layout 3 and Layout 4 there is a considerable improvement in the wave heights inside the harbour basin. The wave heights are always less than the wave tranquility limit of 0.3m. With these Layouts the harbour will be operational from wave tranquility point of view throughout the year. Project authority may decide the feasibility among the Layout 3 and Layout 4 based on the economy. However vessels may face some difficulty while entering to the harbour as they have to sail for a short distance along the waves i.e. broadside waves. Littoral drift studies done at CWPRS (T.R. No. 5357 of February 2016) has also indicated that southward drift is predominant,
- The above statistics is based on the ship observed visual wave data. These data are observed through ships. During stormy conditions ship try to avoid storm track, therefore these data do not contains storm data. Therefore non operational days shall be taken without storm and storms shall add to the non operational days.

भारत सरकार / GOVERNMENT OF INDIA

जल शक्ति मंत्रालय / MINISTRY OF JAL SHAKTI

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION

केंद्रीय जल तथा विद्युत अनुसंधान शाला

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CENTRAL WATER AND POWER RESEARCH STATION

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तटीय जलीय संरचनाए प्रभाग

COASTAL HYDRAULIC STRUCTURES DIVISION

तकनीकी रिपोर्ट संख्या : 6177

नवम्बर, 2023

TECHNICAL REPORT NO :6177

NOVEMBER, 2023

केरल के कासरगोड जिले में स्थित अजानूर में मत्स्य बंदरगाह के लिए तरंगरोधक के डिजाइन के लिए डेस्क और तरंग नलिका अध्ययन

DESK AND WAVE FLUME STUDIES FOR THE DESIGN OF BREAKWATER FOR FISHERY HARBOUR AT AJANUR IN KASARGOD DISTRICT, KERALA

Dr. R.S. Kankara
Director

REPORT DOCUMENTATION SHEET	
Technical Report No. 6177	**Date: NOVEMBER, 2023**

Title: DESK AND WAVE FLUME STUDIES FOR THE DESIGN OF BREAKWATER FOR FISHERY HARBOUR AT AJANUR IN KASARGOD DISTRICT, KERALA

Officers Responsible for Conducting the Studies:

These studies were conducted by Shri B. R. Tayade, Scientist 'D' with the assistance of Dr. Praveen K. M., Scientist 'B', Shri S. P. Jagtap, Assistant Research Officer, Shri G. R. Pardeshi, Shri Deepak Sharma, Research Assistants, Shri Sushant Gupta, LA-II under the supervision of Dr. J. Sinha, Scientist 'E' & Shri A. V. Mahalingaiah, Scientist 'E' and Dr. Prabhat Chandra, Additional Director and overall guidance of Dr. R. S. Kankara, Director, CWPRS, Pune.
Shri Prabhakar Chary, Scientist 'C', Mrs. R.S. Erande, Scientist 'B', Mrs. M. C. Pawar, Assistant Engineer, Shri Yognath, J.E. of RSWG group were associated, while conducting the wave flume studies at CWPRS.

Name and Address of Organization Conducting the Studies

Coastal Hydraulic Structures Division
Central Water and Power Research Station, Pune, India

Name and Address of Authority Sponsoring the Studies:
Chief Engineer,
Harbour Engineering Department,
Kamaleswaram, Manacaud,
Thiruvananthapuram
Kerala – 695009

Synopsis

Harbour Engineering Department, Government of Kerala has a proposal to develop a fishing harbour at Ajanur. In view of this, Chief Engineer, Harbour Engineering Department, Govt of Kerala referred hydraulic model studies to CWPRS for the proposed fishing harbour at Ajanur.

The studies were undertaken and the Mathematical Model Studies for wave tranquillity at the proposed fishing harbour at Ajanur was carried out at CWPRS, Pune. Based on the Mathematical Model Studies, it was suggested to construct 1150 m long north breakwater and 425 m long south breakwater.

Accordingly, desk & wave flume studies were conducted to evolve the cross-section of breakwater based on the actual site survey data and other hydraulic parameters. Design of breakwater with tetrapods in the armour was evolved based on the desk and wave flume studies. The design of breakwater at -4.50 m bed level consists of 6.0 t tetrapod in the seaside armour placed on 1:2 slope in double layer from el. +0.0 m to el. +7.0 m. A 7.0 m wide and 0.5 m thick crest slab with 0.5 m thick parapet wall is proposed at el. +6.5 m. The top of crest slab and parapet wall is kept at el. +7.0 m and +8.0 m respectively. A 6.0 m wide toe-berm is provided at el. +0.0 m consists of 2.0 t to 3.0 t stones with a sea side slope of 1:2. The hydraulic stability tests were conducted in the wave flume by reproducing the section to a Geometrically Similar (GS) model scale of 1:29.

For the design of breakwater, water level of 2.60 m was considered as the Design Water Level (DWL), 1.40 m above the HWL (Storm Surge + Sea level rise). The significant wave height of 4.0 m was considered for the design of breakwater.

Keywords
Breakwater, Storm Surge, Armour, Tetrapod's, Toe-Berm etc.

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Photo 11 : Regular wave test with H_{10} = 5.07 m at MSL = +1.00 m, t = 10 sec

Photo 12 : Regular wave test with H_b = 4.80 m at MLLW = +0.40 m, t = 10 sec

DESK AND WAVE FLUME STUDIES FOR THE DESIGN OF BREAKWATER FOR FISHERY HARBOUR AT AJANUR IN KASARGOD DISTRICT, KERALA

TECHNICAL REPORT NO. 6177 **MONTH: NOVEMBER, 2023**

1.0 INTRODUCTION

Ajanur village (Latitude 12.33^0 N and Longitude 75.18^0 E) in Kasargod District of Kerala is situated on the west coast of India, 15 km south of the district headquarter (Fig. 1). Harbour Engineering Department, Government of Kerala has a proposal to develop a fishing harbour at Ajanur. In view of this, Chief Engineer, Harbour Engineering Department, Govt of Kerala has referred hydraulic model studies to CWPRS for the proposed fishing harbour at Ajanur.

Based on these requirements, Mathematical Model Studies for wave tranquillity for the proposed fishing harbour at Ajanur was carried out at CWPRS, Pune (Technical Report No. 5436 of Nov 2016). As per the layout no. 4 suggested in CWPRS Technical Report the harbour basin area comes out to be about 19 ha. Considering the suggestions given by the Technical Sanction committee of PMMSY schemes, Harbour Engineering Department proposed to increase the basin area upto 26 ha. Accordingly, Additional Mathematical Model Studies for wave tranquillity (CWPRS Technical Note, July 2022) has been carried out for the proposed increased area. Based on the Mathematical Model Studies, it was suggested to construct 1150 m long north breakwater and 425 m long south breakwater.

Accordingly, desk studies were conducted for evolving the conceptual cross-section of the breakwater using empirical methods and past experience of CWPRS and considering the hydraulic/site conditions such as bathymetry, tides and waves prevailing at site. Thereafter, the wave flume studies were conducted for assessing the hydraulic stability of the proposed breakwater cross-section at Ajanur, Dist. Kasargod, Kerala.

This report describes in detail the desk & the wave flume studies carried out to evolve design of the breakwater for achieving tranquil condition in the proposed fishing harbour at Ajanur, Kerala.

2.0 SCOPE OF STUDIES

For the proposed development of fishery harbour at Ajanur in Kasargod district of Kerala, the following hydraulic model studies entrusted to CWPRS by Chief Engineer, Harbour Engineering Department, Thiruvananthapuram:

1. Additional Mathematical Model Studies for wave tranquillity for the revised layout of fishery harbour at Ajanur, Kerala.

2. Desk and wave flume studies for the design of breakwater for fishery harbour at Ajanur in Kasargod district, Kerala.

On the basis of Mathematical Model Studies for wave tranquility for the proposed fishery harbour at Ajanur, 1150 m long north breakwater and 425 m long south breakwater are suggested as shown in Fig. 2.

The scope of the present studies includes evolving the conceptual design for the suggested breakwater based on empirical methods and the conditions prevailing at the site. Further, the conceptual design of the breakwater was assessed for its hydraulic stability by conducting wave flume tests for various design wave conditions.

3.0 SITE CONDITIONS

Ajanur village in Kasargod District is situated about 15km south of district headquarter at Latitude 12.33^0 N and Longitude 75.18^0 E in Kerala state. Majority of village population belongs to fishermen community. At present, the fishermen are operating their boats in open sea & they are facing difficulties in navigating the vessels due to shallow depth & direct wave action.

In view of this, Harbour Engineering Department, Govt of Kerala has a proposal to construct a fishery harbour south of the Chittari River mouth at Ajanur in Kasargod district, Kerala.

4.0 DESIGN CONDITIONS

4.1 Tidal Levels

The tides in the region are semidiurnal in nature. The maximum tidal range at Kasargod is about 1.0 m. The tidal currents are generally parallel to the coastline. The following tidal levels at Kasargod have been considered for the wave flume studies (Reference: Admiralty Chart No. 217 of 2019):

Table 1: Normal Tidal Levels at Kasargod, Kerala

Tides	Level w.r.t Chart Datum
Mean Higher High Water (MHHW/HWL)	+1.40 m
Mean Lower High Water (MLHW)	+1.30 m
Mean Sea Level (MSL)	+1.00 m
Mean Higher Low Water (MHLW)	+0.90 m
Mean Lower Low Water (MLLW/LLWL)	+0.40 m

A Design Water Level (DWL) of 2.60 m was considered including MHHW and 1.20 m above the MHHW i.e Storm Surge (0.80 m) + Sea level rise (0.40 m). These water levels are with respect to Chart Datum (CD). The design of breakwater cross-sections was also tested at HWL, MSL and LLWL water levels.

4.2 Design Wave Conditions

The predominant wave direction at proposed site in Kasargod district is SSW. Following design conditions were considered for the stability of the breakwater against wave attack and to provide tranquil condition in the harbour area:

1. Zero-order (0 to 1 %) damage for the significant wave height of 4.0 m at +2.60 m (DWL) and +1.40 m (HWL).
2. Overtopping is not permitted.
3. The wave periods considered for the tests are 8, 10 and 12 seconds.
4. The stability of the section is also to be assessed at an intermediate water level and low water level.

5.0 DESIGN OF BREAKWATER

The desk and wave flume studies have been conducted for evolving cross-section of the breakwater with tetrapods in the armour layer based on empirical formulae, existing conditions at the site and previous in-house extensive wave flume studies conducted at CWPRS for hydraulic stability of breakwater. The weight of armour units are basically evaluated based on Hudson's formula (as given below):

$$W = \frac{w_r . H_b^{\,3}}{K_D \times (Sr - 1)^3 . \cot\theta}$$

Where,

H_b = Breaking wave height (m)
W = Weight of Armour (t)
w_r = Unit Weight of Armour (t/m^3)
K_D = Stability Coefficient for Breaking Wave Height
S_r = Specific Gravity of Armour relative to Water at the structure (w_r / W_w)
W_w = Unit wt. of sea water (t/m^3)
Cot θ = Slope of armour

The conceptual design cross-section of the breakwater with tetrapods in the armour were evolved based on the desk studies as shown in Fig. 4. The design of breakwater at -4.50 m bed level consists of 6.0 t tetrapod in the seaside armour placed on 1:2 slope in double layer from el. +0.0 m to el. +7.0 m. A 7.0 m wide crest slab with 0.5 m thick parapet wall is proposed with top el. +7.0 m. The top of parapet wall is kept at el. +8.0 m. A 6.0 m wide toe-berm is provided at el. +0.0 m consists of 2.0 t to 3.0 t stones with a sea side slope of 1:2. Secondary layer consists of 0.5 – 1.0 t stones below the armour layer and 200 – 300 kg stones below the toe-berm armour. A 0.30 m thick bedding layer consisting of stones up to 20 kg is provided at -4.50 m bed level.

6.0 HYDRAULIC MODEL STUDIES

6.1 Random Sea Wave Flume

The random sea wave flume having dimensions 90 m (length) x 2 m (width) x 1.50 m (height) was utilised for the wave flume tests as shown in Annexure-I / Photo 1. The system is capable of generating maximum wave height

of 0.4 m at a water depth of 0.6 m for wave periods ranging between 0.3 and 3 sec. The flume facility is equipped with a fully automated computerised random wave generating system comprising of computer, hydro-servo system and wave board assembly. The command signals are sent by computer to the servo-valve through which pressurised oil supplied by hydraulic power pack flows into the actuator. A *To* and *Fro* motion of the piston drives the wave board, which in turn generates waves in the flume.

6.2 Wave Measurement and Calibration

The wave heights were measured by capacitance type wave probes. A gauge was fixed in front of the model and was analysed by computer. The desired wave conditions in front of the model were obtained by matching of desired spectrum and achieved spectrum by iterative procedure.

6.3 Wave Flume Test Procedure

The cross-section of the breakwater was tested under a normal attack of waves in a 2-D wave flume for its hydraulic stability (Photo 1). The model of breakwater cross-section was constructed to a Geometrically Similar (GS) scale in the wave flume. The dimensions of the random wave flume are 90 m length, 2 m width and 1.5 m depth wherein both regular as well as random waves of desired wave height/wave period and desired standard wave spectrum respectively can be generated. Before starting the test, the number of tetrapods provided in the armour and stones in the toe-berm were counted. After conducting the tests for one-hour duration, the number of tetrapods/stones, if any, displaced from its original position were recorded and percentage of damage to the armour/toe-berm of breakwater was determined. During the test, the extent of splashing/overtopping over the crest was also recorded. The damage is expressed as percentage of number of tetrapods/stones displaced from their position. The percentage of damage is equal to "Number of units displaced/total no. of units used in the respective layer".

6.4 Model Scale

The model tests for design of cross-section of the breakwater were conducted in 2-D wave flume by reproducing the section to a Geometrically Similar scale of 1:29. The model was based on Froude's criterion of similitude. Various scales obtained are as follows:

Table 2: Scale Ratio for Model Studies of the Breakwater

Model scale 1:29		
Length	- L	= 1:29
Area	- L^2	= 1:841
Volume	- L^3	= 1:24389
Time	- $L^{1/2}$	= 1:5.385
Velocity	- $L^{1/2}$	= 1:5.385

6.5 Gradation of Stones

Details of various gradations of stones in prototype of the trunk of the breakwater and those used in the model having scale 1:29 are given table 3:

Table 3: Gradation of Stones for Trunk of Breakwater

Prototype		Model (Scale 1:29)	
Average	**Gradation**	**Average**	**Gradation**
2.5 t	2 – 3 t	100 gm	80 to 120 gm
1.5 t	1 – 2 t	60 gm	40 to 80 gm
0.75 t	0.5 – 1 t	30 gm	20 to 40 gm
250 kg	200 – 300 kg	10 gm	8 to 12 gm

6.6 2-D Wave Flume Tests

The cross section of the breakwater, as shown in Fig. 4, was constructed with a Geometrically Similar model scale of 1:29 in the wave flume. Tests were conducted considering both random and regular wave conditions to assess the stability of the breakwater. For random waves, 4.0 m significant wave height (H_s) was considered. To achieve this H_s, Pierson-Moskowitz (PM) spectrum was used for acquiring desired wave height in the 90 m wave flume. For acquiring desired

regular wave height i.e. non breaking wave height in front of the breakwater, series of wave height analysis was carried out with the help of In-house computer program.

The tests were carried out at DWL, MHHW, MSL & MLWL with various wave conditions. The tests were conducted for one-hour duration each in the model corresponding to about 5.39 hours (approx.) in the prototype. The objectives of the tests were to check hydraulic stability of the breakwater against various wave conditions likely to occur in the vicinity of proposed fishery harbour area at Ajanur, Kasargod district.

The details of the wave flume tests were conducted for breakwater cross-section at -4.50 m bed level with random waves are described as follows:

1) Initially, a test was conducted with random waves at a significant wave height (H_s) of 4.05 m at Design Water Level (+2.60 m) for one hour duration (corresponding to 5.39 hours in prototype) using PM (Pierson-Moskowitz) spectrum. There was no overtopping and moderate splashing observed during the test. The test showed that there was no damage occurred to both armour layer and toe-berm (Photograph No. 2).

2) An endurance test was conducted at Design Water Level (+2.60 m) with random waves using PM (Pierson-Moskowitz) spectrum for the significant wave height of 4.85 m (120% of H_s i.e. 4.80 m) for one hour duration. During the test, it was observed that there was moderate splashing but no overtopping. After conducting the test for one hour duration, no damage was observed in the armour and the toe-berm (Photograph No. 3).

3) Further, a test was conducted with random waves at a significant wave height (H_s) of 4.0 m at the Mean Higher High Water (MHHW) (+1.40 m) for one hour duration using PM (Pierson-Moskowitz) spectrum. There was no splashing and no overtopping observed during the test. After the test, it was observed that there was no damage occurred in the armour as well as in the toe-berm (Photograph No. 4).

4) Another test was conducted with random waves at a significant wave height (H_s) of 3.97 m at Mean Sea Level (+1.00 m) for one hour duration (corresponding to 5.39 hours in prototype) using PM (Pierson-Moskowitz) spectrum. During the test, no splashing and no overtopping was observed. There was no damage to the toe-berm as well as to the armour observed after the test (Photograph No. 5).

5) A test was conducted with random waves at a significant wave height (Hs) of 3.76 m at Mean Lower Low Water Level (+0.40 m) for one hour duration (corresponding to 5.39 hours in prototype) using PM (Pierson-Moskowitz) spectrum. No splashing and no overtopping were observed during the test. After the test, it was observed that there was no damage to the toe- berm as well as to the armour (Photograph No. 6).

From the past experiences during the model testing, it has been revealed that many-times the structures were also susceptible to undergone damages during the regular wave conditions, therefore the cross-section of breakwater was also tested in the regular wave conditions.

The details of **regular wave testing** on the breakwater cross-section are as follows:

6) A test was conducted, at the Design Water Level of +2.60 m under the attack of regular waves of 10 sec period with wave height (H_{10}) of 5.0 m. There was minor overtopping and moderate splashing of waves observed during the test. The maximum wave run-up was upto +5.85 m and run-down was up to +0.72 m were observed. After conducting the test under the condition for one hour in the wave flume, no damage was observed in the armour layer and in the toe-berm (Photograph No. 7).

7) A test was also carried out under the attack of regular (monochromatic) waves at Mean Higher High Water (+1.40 m). The duration of test was one hour in the model corresponding to about 5.39 hours in the prototype. The test was conducted for wave height of (H_{10}) of 5.12 m with 12 second period. During the test, it was noticed that the maximum wave run-up was upto +5.0 m and run-down was up to +0.15 m. There

was no damage observed to the toe-berm stones and to the armour layer after the test. There was no splashing and no overtopping of waves observed (Photograph No. 8).

8) Further, a test was conducted for one hour duration at Mean Higher High Water (MHHW) of +1.40 m under the attack of regular waves of 10 sec period with wave height (H_{10}) of 5.0 m. During the test, no overtopping and no splashing was observed. The maximum wave run-up was upto +5.10 m and run-down was up to (-) 0.20 m. No damage was observed in the armour layer and in the toe-berm (Photograph No. 9).

9) Another test was conducted for one hour duration at Mean Higher High Water (MHHW) of +1.40 m under the attack of regular waves of 8 sec period with wave height (H_{10}) of 5.0 m. During the test, no splashing and no overtopping was observed. The max wave run-up was up to +4.25 m and run-down up to +0.00 m were observed. After conducting the test, there was no damage observed in the armour layer and toe-berm (Photograph No. 10).

10) A test was also carried out under the attack of regular (monochromatic) waves at Mean Sea Level (+1.00 m). The duration of test was one hour in the model corresponding to about 5.39 hours in the prototype. The test was conducted for wave height of 5.07 m (H_{10}) with 10 second period. During the test, it was observed that the maximum wave run-up and run-down was up to +3.50 m and up to (-) 0.50 m respectively. There was no damage observed in the toe-berm as well in the armour. No splashing and no overtopping of waves were observed (Photograph No. 11).

11) Another test was conducted for one hour duration at Mean Lower Low Water Level (MLLW) of +0.40 m under the attack of regular waves of 10 sec period with wave height (H_b) of 4.80 m. During the test, no splashing and no overtopping was observed. The max wave run-up was up to +3.50 m and run-down up to (-) 1.10 m were observed. After conducting

the test, there was no damage observed in the armour layer and toe-berm (Photograph No. 12).

All results of tests conducted for the cross-section of the breakwater (trunk portion) are summarized in the Table 4, and photographs of all the tests are enclosed as Annexure-V.

Overall, the cross-section of the breakwater was found stable against the higher wave action at high water level. No damage to the toe-berm and to the armour layer of breakwater were observed during the tests. Therefore, the section was found to be hydraulically stable against the design wave conditions adopted for the design of the proposed breakwater for fishery harbour at Ajanur, Dist Kasargod, Kerala.

Table 4: Summary of the Wave Flume Test conducted at RSWG

Name of the Project – Breakwater for fishery harbour at Ajanur in Kasargod district, Kerala
Model Scale = 1:29, Armour Unit = 6 t Tetrapod, Toe-Berm = Stone (2 – 3 t)
DWL = +2.60 m, MHHW = +1.40 m, MSL = +1.00 m, MLLW = +0.40 m
Test Duration = 1 hour (5.39 Hrs Proto), Bed Level = -4.50 m
Spectrum - Pierson-Moskowitz Spectrum

Sr. No	Water Level	Wave Height	Splashing	Over-topping	Run-up	Run-down	Damage		Remark	Photograph No.
							Toe-berm	Armour		
Random Wave Tests										
1	DWL	H_s = 4.05 m	Moderate	Nil	N.A.	N.A.	Nil	Nil		2
2	DWL	H_s = 4.85 m	Moderate	Nil	N.A.	N.A.	Nil	Nil	Endurance Test	3
3	MHHW	H_s = 4.0 m	Nil	Nil	N.A.	N.A.	Nil	Nil		4
4	MSL	H_s= 3.97 m	Nil	Nil	N.A.	N.A.	Nil	Nil		5
5	MLLW	H_s= 3.76 m	Nil	Nil	N.A.	N.A.	Nil	Nil		6
Regular Wave Tests										
6	DWL	H_{10} = 5.0 m	Moderate	Minor	Upto +5.85 m	Upto +0.72 m	Nil	Nil	T = 10 sec	7
7	MHHW	H_{10} = 5.12 m	Minor	Nil	Upto +5.0 m	Upto +0.15 m	Nil	Nil	T = 12 sec	8
8	MHHW	H_{10} = 5.0 m	Nil	Nil	Upto +5.10 m	Upto (-)0.20 m	Nil	Nil	T = 10 sec	9
9	MHHW	H_{10} = 5.0 m	Nil	Nil	Upto +4.25 m	Upto +0.0 m	Nil	Nil	T = 8 sec	10
10	MSL	H_{10} = 5.07 m	Nil	Nil	Upto +3.50 m	Upto (-)0.50 m	Nil	Nil	T = 10 sec	11
11	MLLW	H_b = 4.80 m	Nil	Nil	Upto +3.50 m	Upto (-)1.10 m	Nil	Nil	T = 10 sec	12

7.0 RECOMMENDED CROSS-SECTIONS OF THE BREAKWATER

After conducting several tests, the cross-section of the breakwater at -4.50 m bed level was found stable against various wave conditions. The details of the cross-section of the breakwater at various bed levels are as follows:

1) Trunk Portion at -2.0 m Bed Level (to be adopted from -2.0 m to +0.0 m Bed level)

The cross-section is designed for the -2.0 m bed level as shown in Fig. 3. This cross-section may be adopted from -2.0 m to +0.0 m bed level range. The cross-section of the breakwater consists of 2 t tetrapods provided in the armour layer with 1:2 slope on the sea-side from el. +2.20 m to +7.0 m and 0.5 to 1.0 t stones provided in the armour with 1:2 slope on the leeside. A 4.0 m wide toe-berm on the seaside consists of 0.5 to 1 t stones is kept at el. +2.20 m. Secondary layer consists of 200 to 300 kg stones provided below the armour layer and 50 to 100 kg stones provided below the toe-berm and leeside armour. Core consists of 20 to 50 kg stones and 0.30 m thick bedding layer consists of stones up to 20 kg. A PCC crest of 0.5 m thick is provided at el. +6.50 m soffit level with sea-side parapet top at el. +8.0 m. A clear carriageway width of 7 m is provided on the crest slab for the movement of vehicles / machineries in future during the inspection / supervision or maintenance purpose.

2) Trunk Portion at -4.50 m Bed Level (to be adopted from -2.0 m to -4.50 m Bed level)

The cross-section of breakwater at -4.50 m bed level is shown in Fig. 4. The cross-section of the breakwater consists of 6 t tetrapods provided in the armour layer with 1:2 slope on the sea-side from el. +0.0 m to +7.0 m and 1 to 2 t stones provided in the armour with 1:2 slope on the leeside. A 6.0 m wide toe-berm on seaside is kept at el. +0.0 m consists of 2 to 3 t stones. The secondary layer consists of 0.5 to 1.0 t stones provided below the armour layer and 200 to 300 kg stones provided below the toe-berm and 100 to 200 kg stones provided below the leeside armour. Core consists of 20 to 100 kg stones and 0.30 m thick bedding layer consists of stones up to 20 kg is provided at

-4.50 m bed level. A 7.0 m wide PCC crest slab of 0.5 m thick is provided at el. +6.50 m soffit level with sea-side parapet top at el. +8.0 m.

3) Roundhead at -4.50 m Bed Level

The cross-section and plan of roundhead portion of breakwater at -4.50 m bed level are shown in Figs. 5 & 6 respectively. The section consists of 8 t tetrapods placed in the armour (double layer) on 1:2 slope and are supported with the 6.0 m wide toe-berm consisting of 3 to 4 t stones at el. +0.0 m. A 8.0 m wide PCC crest slab is provided with top el. +8.0 m. A clear carriageway width of 8 m is provided on the crest slab for the movement of vehicles / machineries in future during the inspection / supervision or maintenance purpose. Secondary layer consists of 0.5 to 1.0 t stones provided below the armour layer and below the toe-berm. Core consists of 20-100 kg stones. A 0.3 m thick bedding layer is provided with stones upto 20 kg.

8.0 CONCLUDING REMARKS AND RECOMMENDATIONS

Based on the desk and the wave flume studies carried out for design of the breakwater for fishery harbour at Ajanur in Kasargod District, Kerala, the following concluding remarks are drawn:

1. The recommended cross-section of the breakwater with tetrapods in the armour layer is shown in Fig. 3 to Fig. 6. The cross section is hydraulically stable under the design wave conditions & therefore, recommended to implement at the proposed site.
2. The end of the breakwater should be protected by providing proper roundhead as shown in Figs. 5 & 6. The construction phasing may be adhered, in order to have a safety and economy of the project. If, the construction of the breakwater may not be possible during one season, as such, a temporary roundhead at the end portion may be provided wherever the work is curtailed.
3. The density of concrete and stones to be used for construction of the breakwater should be about 2.4 t / m^3 and 2.6 t / m^3, respectively.

4. There should not be any deviation from the design during the construction of the breakwater in respect of levels, slopes and weights of the stones.

5. The crest slab and the parapet wall provided at the crest of the breakwater may be constructed monolithically.

6. The packing density of the 2 t Tetrapods, 6 t Tetrapods and 8 t Tetrapods (double layer) in the armour layer of breakwater is 117 Nos., 56 Nos. and 47 Nos. per 100 sq. m. of area. The specification of 2 t Tetrapods, 6 t Tetrapods and 8 t Tetrapods are enclosed as Annexure-II, III and IV respectively.

7. All levels of the proposed breakwater should be correlated with Chart Datum before construction at the site.

8. The grading of the stones to be used in the construction for the breakwater should be as follows :

2 – 3 t stones	-	50% stones should be higher than 2.50 t
1 – 2 t stones	-	50% stones should be higher than 1.50 t
0.5 – 1 t stones	-	50% stones should be higher than 0.75 t
200 – 300 kg stones	-	50% stones should be higher than 250 kg
100 – 200 kg stones	-	50% stones should be higher than 150 kg
20 – 100 kg stones	-	75% stones should be higher than 60 kg

9. The rubble mound structures are flexible structures and it is essential to monitor and maintain them regularly. Therefore, periodic survey of the breakwater and maintenance of the breakwater, as and when any damage occurs may be undertaken.

10. It is suggested to carry out geotechnical investigations to check the probable sinkage at the site before the construction of the breakwater.

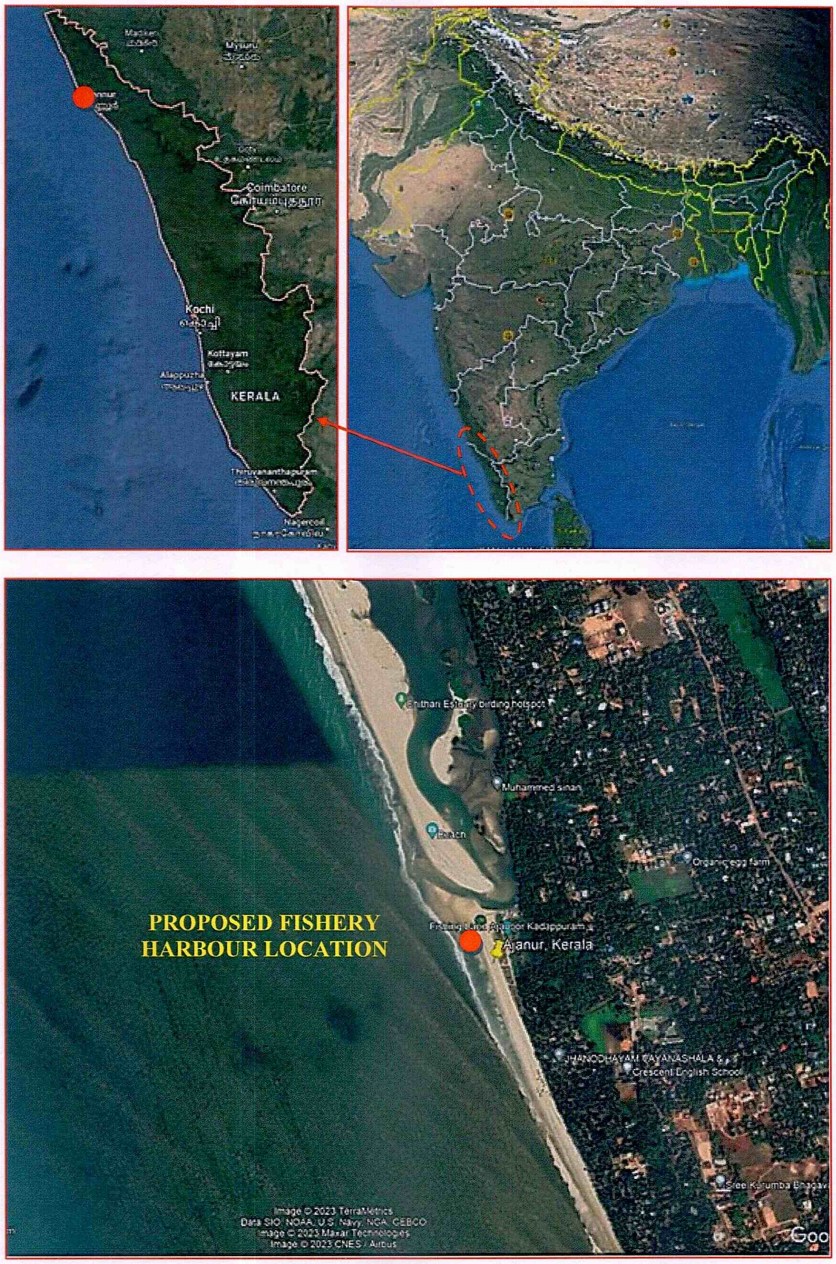


Fig. 1: Index and Location Map of Ajanur, Kasargod District, Kerala.

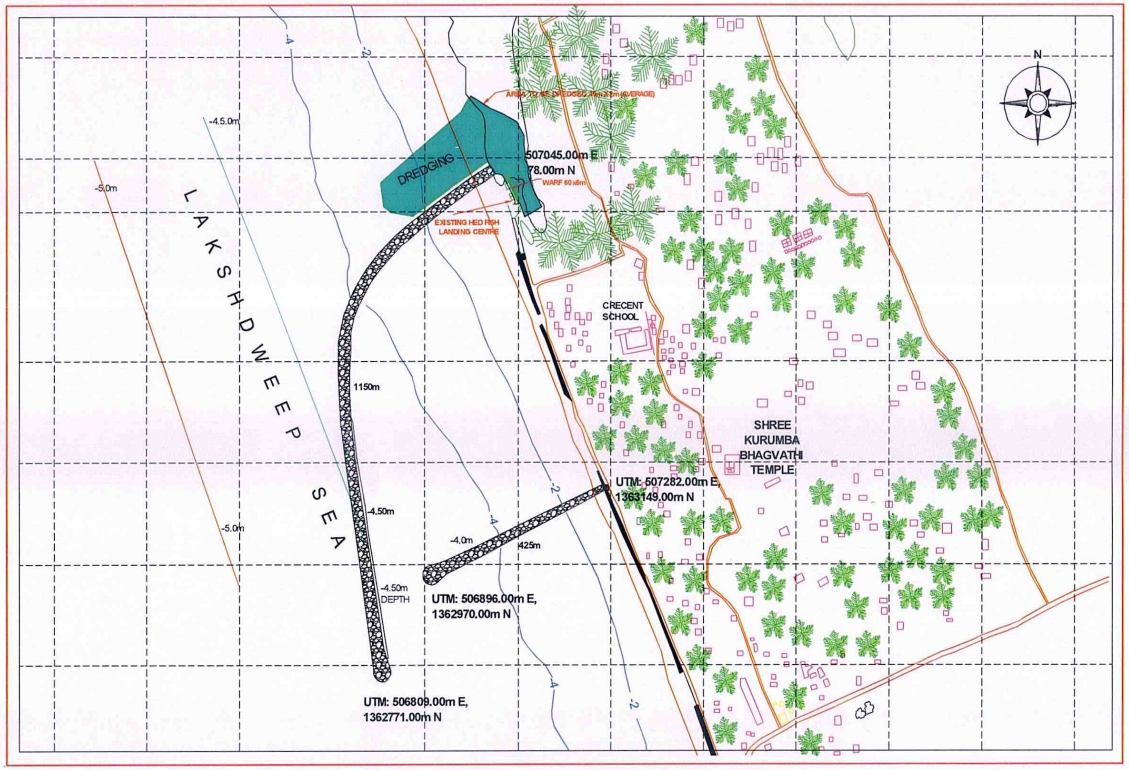


Fig. 2: Layout Plan for Proposed Fishing Harbour at Ajanur, Kasargod District, Kerala

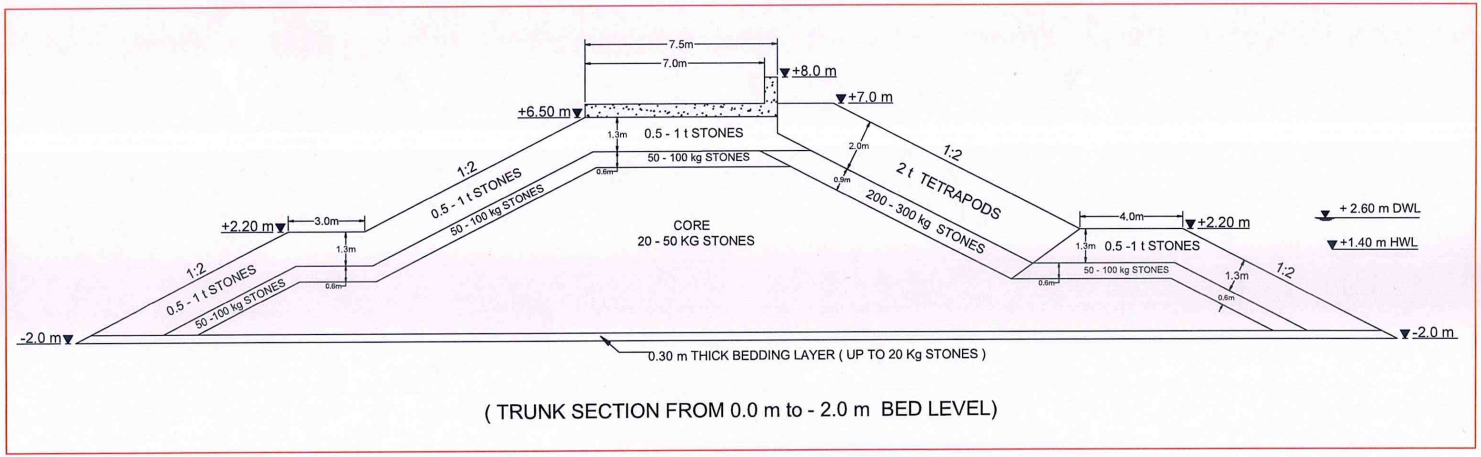


Fig. 3: Design Cross-Section of Breakwater at -2.0 m Bed Level at Ajanur, Kasargod District, Kerala

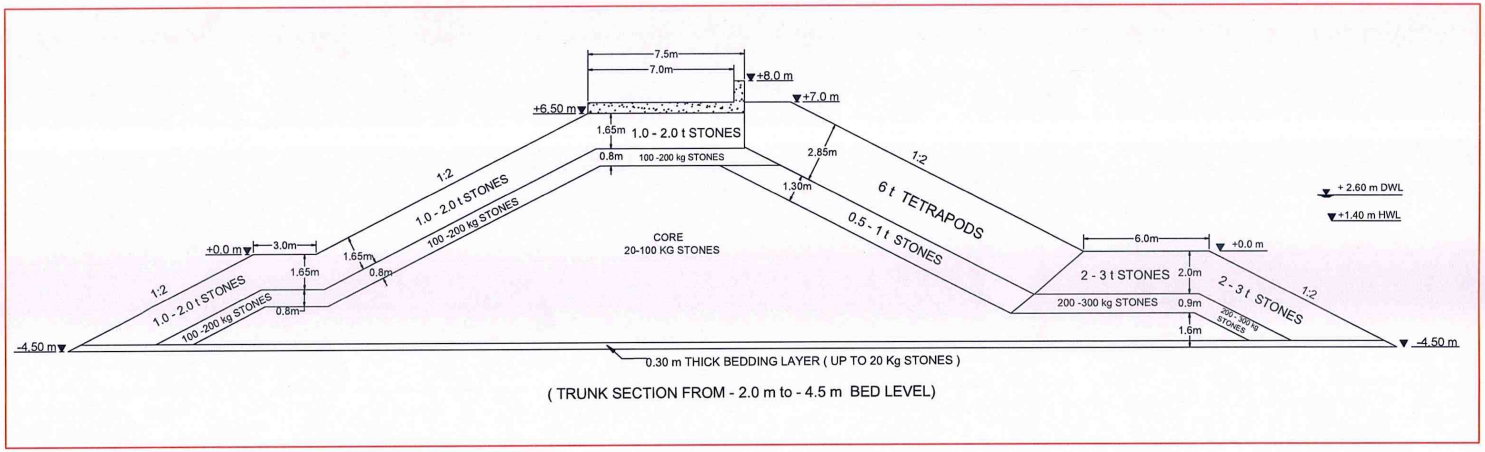


Fig. 4: Design Cross-Section of Breakwater at -4.50 m Bed Level at Ajanur, Kasargod District, Kerala

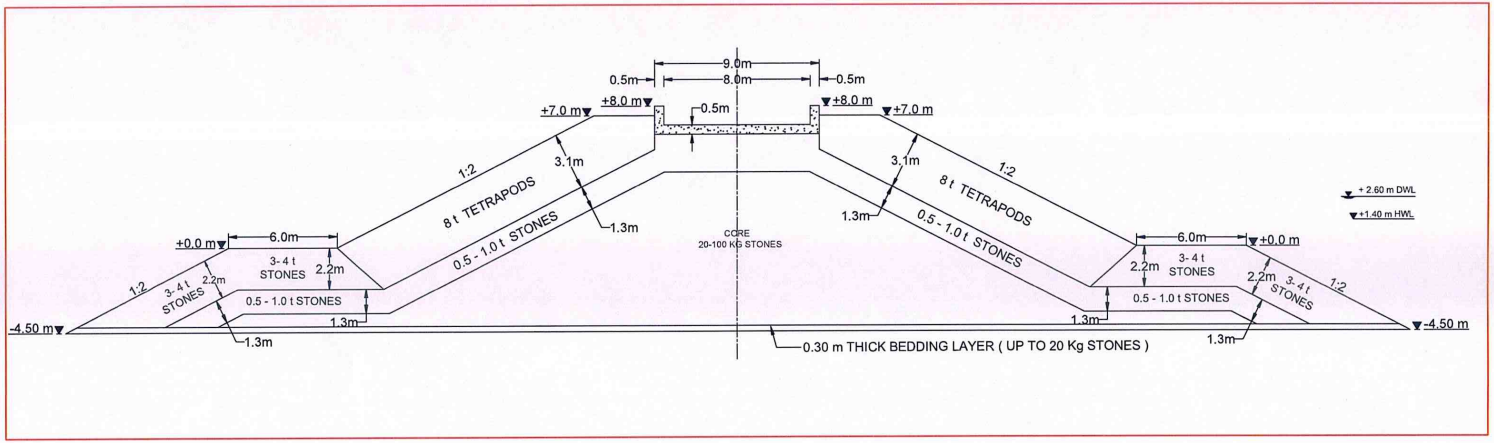


Fig. 5: Roundhead Section of Breakwater at -4.50 m Bed Level at Ajanur, Kasargod District, Kerala

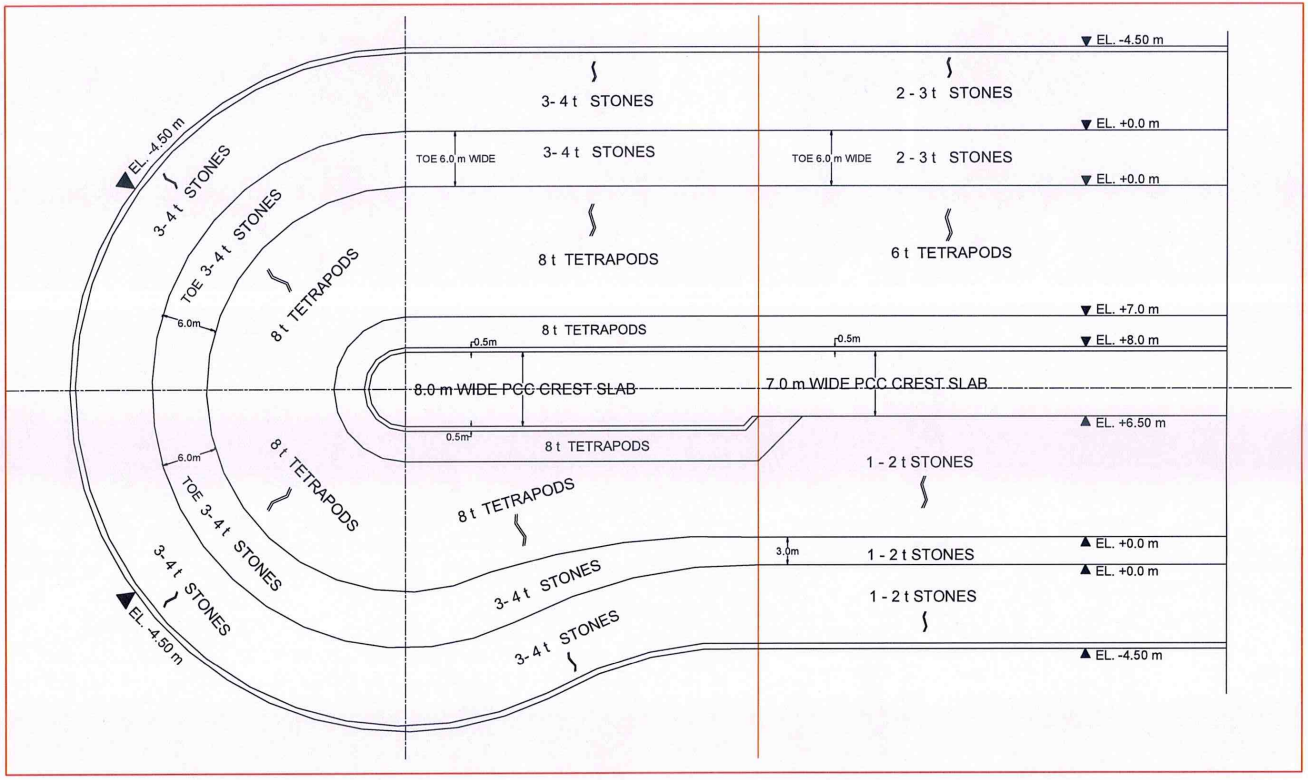
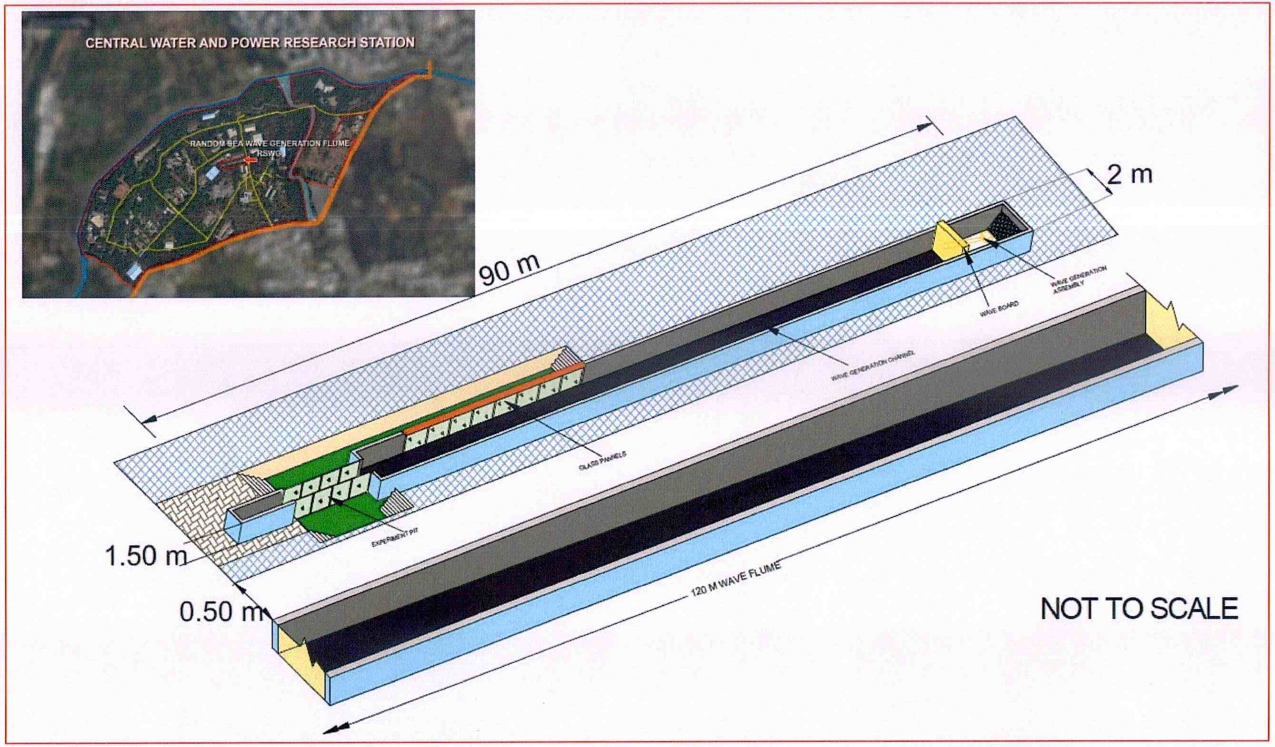


Fig. 6: Plan of Roundhead portion of Breakwater at -4.50 m Bed Level at Ajanur, Kasargod District, Kerala

Annexure I



Random Sea Wave Generation Flume (90 m) Facility at CWPRS, Pune

Annexure – II

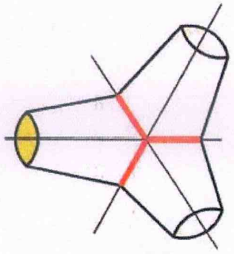
TETRAPOD SPECIFICATION

For 2 T Tetrapod

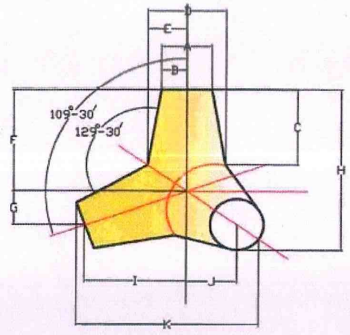
Wt. of Tetrapod	W =	2	T
Density of Concrete	w =	2.4	t/cu. m.
Vol. of Tetrapod	V =	0.833	Cu. meter
Overall dim. of Tetrapod	H =	1.433	meter

Dimensions of Armour Units in meter

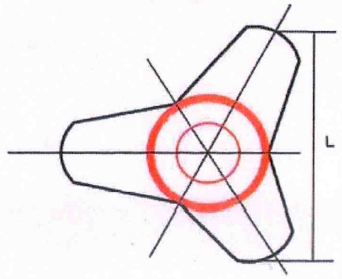
A	0.302*H	0.43
B	0.151*H	0.22
C	0.477*H	0.68
D	0.470*H	0.67
E	0.235*H	0.34
F	0.644*H	0.92
G	0.215*H	0.31
I	0.606*H	0.87
J	0.303*H	0.43
K	1.091*H	1.56
L	1.201*H	1.72



BOTTOM



ELEVATION



PLAN

Armour layer Thickness (2 Units) = 1.361 * H (Double Layer)
i.e = 1.950 meter

Placing Density (N)

Number Of Tetrapods (Two Layers, Random Placed) Per Unit Area

N = n * K? * (1-P/100) * (w/W)**2/3

Where,

Layer coeff.	K? =	1.04	constant	N =	1.174 per sq. m. area
Porosity	P=	50	%	**N =**	**117 per 100 sq. m. area**
No. of Layers	n=	2	nos.		

Specification for 2 t Tetrapod

Annexure – III

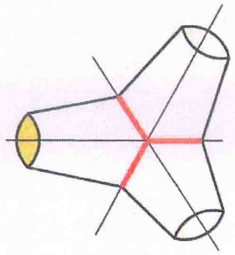
TETRAPOD SPECIFICATION

For 6 T Tetrapod

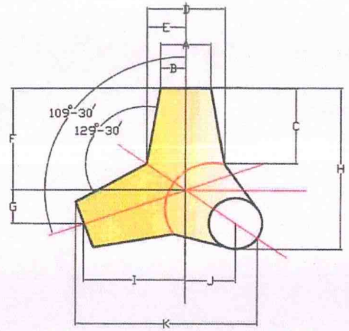
Wt. of Tetrapod	W =	6	T
Density of Concrete	w =	2.4	t/cu. m.
Vol. of Tetrapod	V =	2.500	Cu. meter
Overall dim. of Tetrapod	H =	2.059	meter

Dimensions of Armour Units in meter

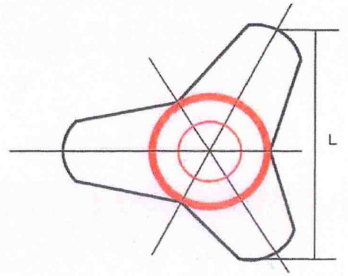
A	0.302*H	0.62
B	0.151*H	0.31
C	0.477*H	0.98
D	0.470*H	0.97
E	0.235*H	0.48
F	0.644*H	1.33
G	0.215*H	0.44
I	0.606*H	1.25
J	0.303*H	0.62
K	1.091*H	2.25
L	1.201*H	2.47



BOTTOM



ELEVATION



PLAN

Armour layer Thickness (2 Units) = 1.361 * H (Double Layer)
i.e = 2.803 meter

Placing Density (N)
Number Of Tetrapods (Two Layers, Random Placed) Per Unit Area
N = n * K? * (1-P/100) * (w/W)**2/3

Where,				N =	0.565 per sq. m. area
Layer coeff.	K? =	1.04	constant	**N =**	**56 per 100 sq. m. area**
Porosity	P=	50	%		
No. of Layers	n=	2	nos.		

Specification for 6 t Tetrapod

Annexure – IV

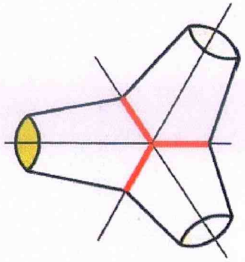
TETRAPOD SPECIFICATION

For 8 T Tetrapod

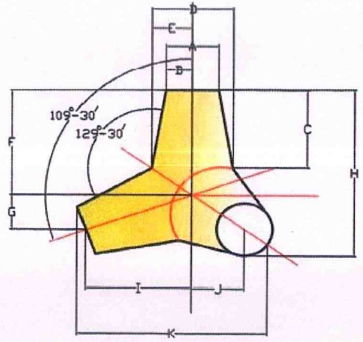
Wt. of Tetrapod	W =	8	T
Density of Concrete	w =	2.4	t/cu. m.
Vol. of Tetrapod	V =	3.333	Cu. meter
Overall dim. of Tetrapod	H =	2.264	meter

Dimensions of Armour Units in meter

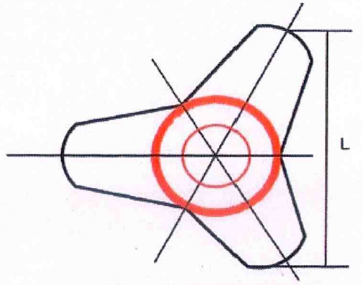
A	0.302*H	0.68
B	0.151*H	0.34
C	0.477*H	1.08
D	0.470*H	1.06
E	0.235*H	0.53
F	0.644*H	1.46
G	0.215*H	0.49
I	0.606*H	1.37
J	0.303*H	0.69
K	1.091*H	2.47
L	1.201*H	2.72



BOTTOM



ELEVATION



Armour layer Thickness (2 Units) = 1.361 * H (Double Layer)
i.e = 3.082 meter

Placing Density (N)

Number Of Tetrapods (Two Layers, Random Placed) Per Unit Area

N = n * KΔ * (1-P/100) * (w/W)**2/3

Where,

Layer coeff.	KΔ =	1.04	constant
Porosity	P=	50	%
No. of Layers	n=	2	nos.

N =	0.466	per sq. m. area
N =	**47**	**per 100 sq. m. area**

Specification for 8 t Tetrapod

Annexure - V



Photo 1: 90 m long RSWG wave flume facility at CWPRS

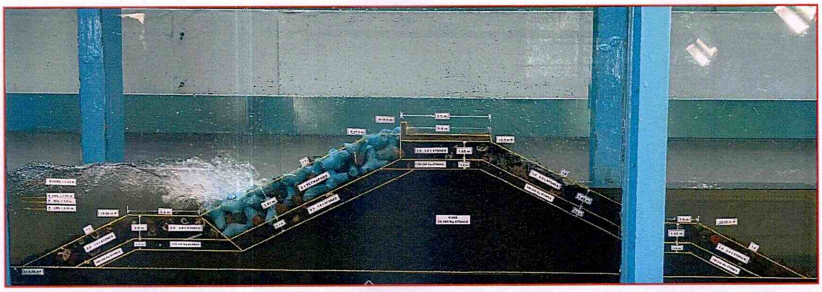


Photo 2: Random wave test with H_s = 4.05 m at DWL = +2.60 m



Photo 3: Random wave test with H_s = 4.85 m at DWL = +2.60 m (Endurance Test)

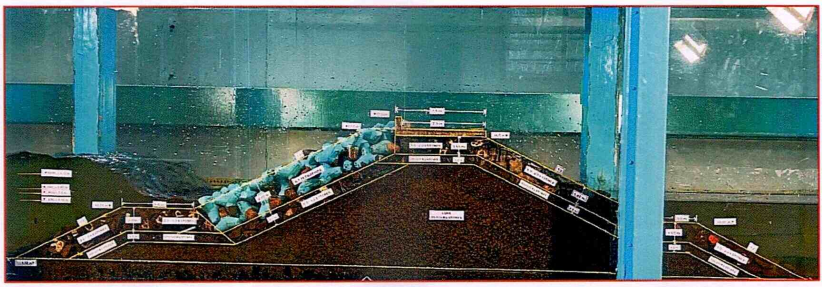


Photo 4: Random wave test with H_s = 4.0 m at MHHW = +1.40 m

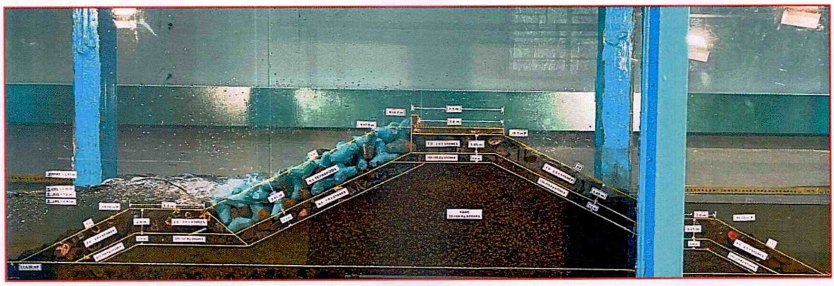


Photo 5: Random wave test with H_s = 3.97 m at MSL = +1.00 m

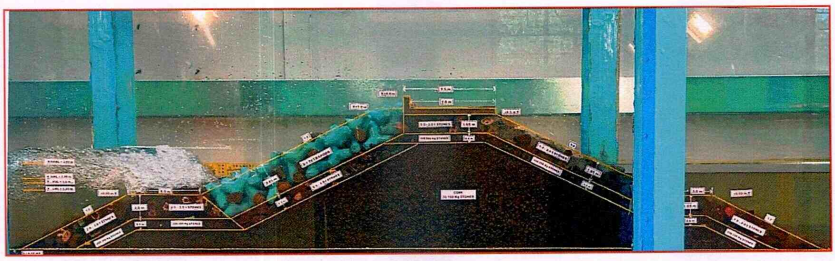


Photo 6: Random wave test with H_s = 3.76 m at MLLW = +0.40 m

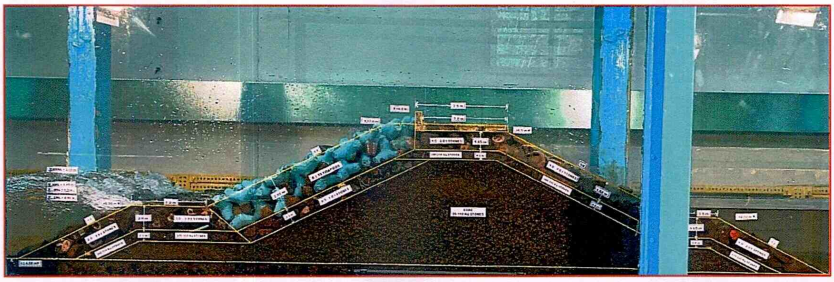


Photo 7: Regular wave test with H_{10} = 5.0 m at DWL = +2.60 m, t = 10 sec

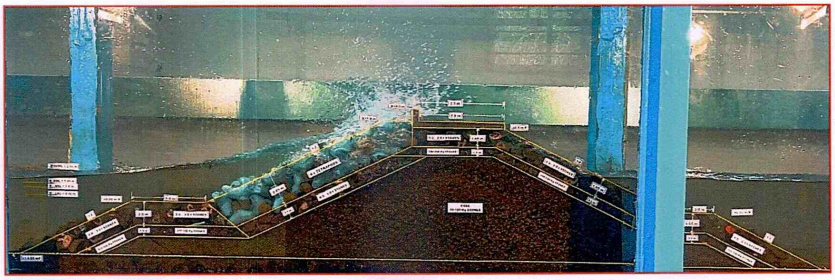


Photo 8: Regular wave test with H_{10} = 5.12 m at MHHW = +1.40 m, t = 12 sec

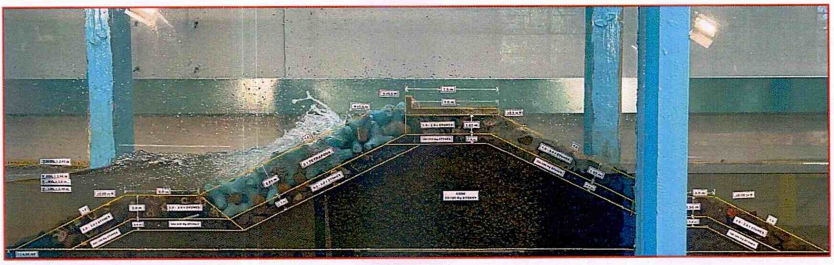


Photo 9: Regular wave test with H_{10} = 5.0 m at MHHW = +1.40 m, t = 10 sec

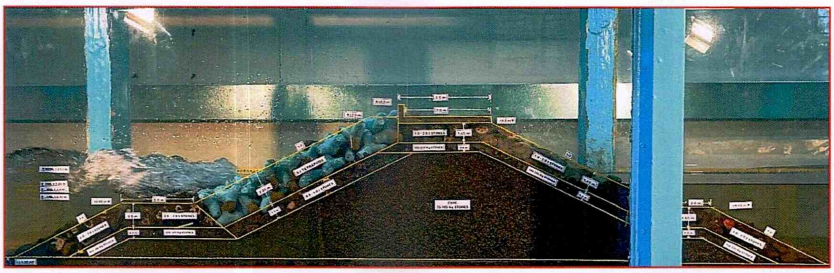


Photo 10: Regular wave test with H_{10} = 5.0 m at MHHW = +1.40 m, t = 8 sec

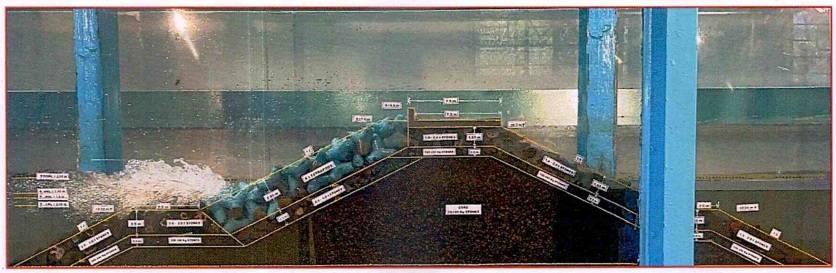


Photo 11: Regular wave test with H_{10} = 5.07 m at MSL = +1.00 m, t = 10 sec

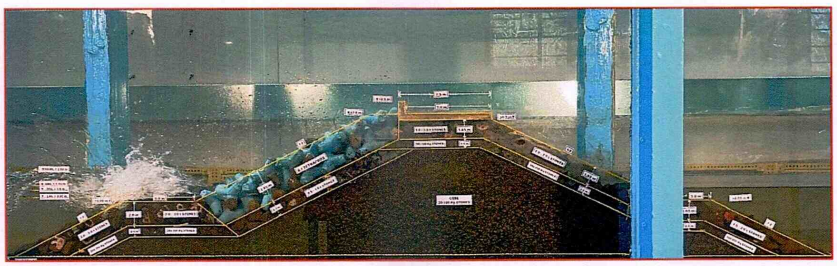


Photo 12: Regular wave test with H_b = 4.80 m at MLLW = +0.40 m, t = 10 sec

भारत सरकार / Government of India
जल शक्ति मंत्रालय / Ministry of Jal Shakti
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
Department of Water Resources, River Development and
Ganga Rejuvenation
केन्द्रीय जल और विद्युत अनुसंधान शाला
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CENTRAL WATER & POWER RESEARCH STATION
Khadakwasla, Pune – 411024

MATHEMATICAL MODELLING FOR COASTAL ENGINEERING DIVISION
(Coastal and Offshore Engineering Laboratory)

TECHNICAL REPORT No.: 6283
July 2024

मछली पकड़ने के बंदरगाह के निर्माण के कारण जल-गत्यात्मकता और गाद का आकलन करने के लिए गणितीय प्रतिमान अध्ययन अजनूर, केरल

MATHEMATICAL MODEL STUDIES TO ASSESS HYDRODYNAMICS AND SILTATION DUE TO CONSTRUCTION OF FISHING HARBOUR AT AJANUR, KERALA

Dr. R. S. Kankara
Director

REPORT DOCUMENTATION SHEET

Technical Report No. 6283 **Date: July 2024**

Title: MATHEMATICAL MODEL STUDIES TO ASSESS HYDRODYNAMICS AND SILTATION DUE TO CONSTRUCTION OF FISHING HARBOUR AT AJANUR, KERALA

Officers Responsible for Conducting the Studies

The studies were conducted by Boora Krishna, Scientist 'B', Dr. Naren Scientist 'B' and Naval Jagatap, Scientist 'B' under the supervision of Dr. Jiweshwar Sinha, Scientist 'E' and Dr. Prabhat Chandra, Additional Director and overall supervision of Dr. R. S. Kankara, Director, CWPRS, Pune.

Name and Address of Organization Conducting the Studies

Mathematical Modelling for Coastal Engineering Division
Central Water and Power Research Station, Pune - 411 024

Name and Address of Authority Sponsoring the Studies

Chief Engineer,
Harbour Engineering Department (HED),
Kamaleshwaram, Manacaud - P.O, Thiruvanathapuram – 695 009

Synopsis

Mathematical model studies to assess hydrodynamics and sedimentation aspects for the proposed development of fishing harbour at Ajanur was referred to CWPRS by Chief Engineer, HED, Kerala. The model simulations for hydrodynamics and sedimentation were carried out for the existing and the proposed condition.

As per the wave and littoral drift simulation results the proposed layout having 1150m long north breakwater, 425m long south breakwater, 435m breakwater as a river training work was studied for hydrodynamics and siltation point of view. Further, dredging upto -2m in the approach channel of the Chittari river mouth with appropriate dredging along the river was incorporated in the model. Also, dredging upto -4m in the harbour basin was considered in the hydrodynamic model simulations. The model results revealed that the annual sedimentation i.e. depth of deposition for the proposed condition in the harbour basin would be about 0.03m per year whereas depth of deposition at the river mouth would be about 0.045m in a year. A reduction in current speed due to the proposed development in the channel i.e. dredging of the channel up to -2m as well as in the proposed harbour basin would cause the loss of depth in the site. Further, an annual sedimentation of about 0.05m along the north and south of the breakwaters is also observed from the model results. Based on the model results, the proposed layout of the training works and the harbour basin is found to be suitable with the prevailing conditions at the site.

Key Words: Mathematical Model, Breakwater, Current, Sedimentation, MIKE 21

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MATHEMATICAL MODEL STUDIES TO ASSESS HYDRODYNAMICS AND SILTATION DUE TO CONSTRUCTION OF FISHING HARBOUR AT AJANUR, KERALA

Technical Report No.:6283	DATE: July 2024

1.0 INTRODUCTION

Harbour Engineering Department (HED), Government of Kerala proposed to develop a fishing harbour at Ajanur situated about 15km south of Kasaragod district. Ajanur fishing harbour is located geographically at Latitude 12.33^0 N and Longitude 75.18^0 E in Kerala state on the western coast of India. Fig. 1 shows the location map of Ajanur fishing harbour.

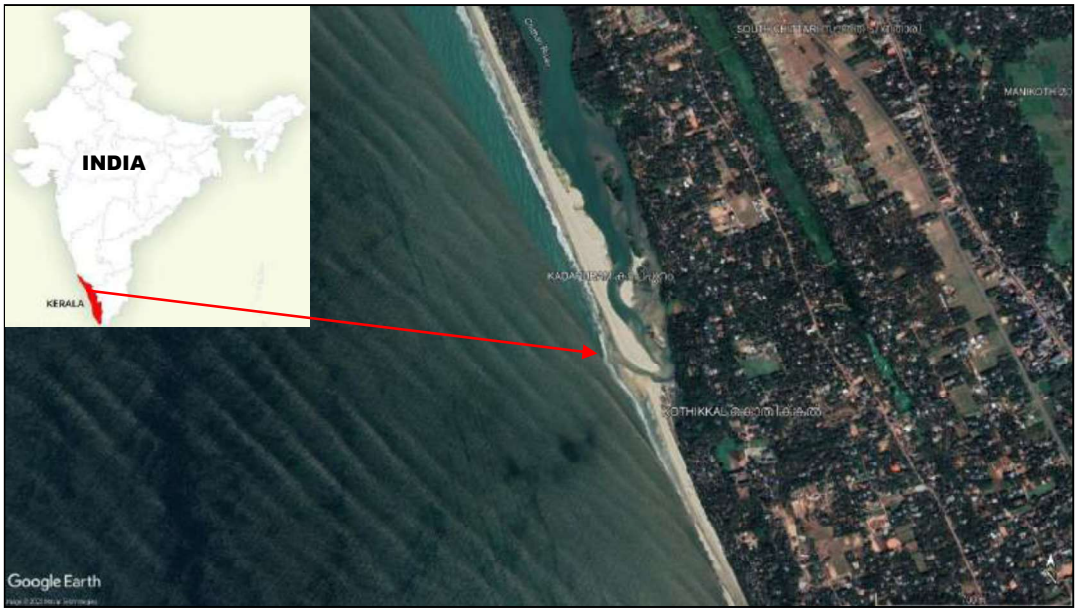


Figure 1: Location of Site at Ajanur

CWPRS carried out wave model studies on the same study area in the year 2016. These studies proposed one final layout of fishing harbour. As per the CWPRS 2016 report vide T. R. No. 5436, Nov 2016, the harbour basin area is about 19 hectares. Considering the future expansion as suggested by the Technical Sanction Committee of Pradhan Mantri Matsya Sampada Yojana (PMMSY) scheme vide HED Letter No. D4/9509/06/CE dated 16-06-2022, HED proposed a revised layout of the Ajanur fishing harbour. The revised layout consists of 1150m long north breakwater, 425m long south breakwater and 435m breakwater as a river training work near the mouth of Chittari river. River training work is proposed in the present layout considering two major coastal processes: - (i) control of shifting and closing of Chittari River mouth due to sedimentation (ii) Southward littoral drift and littoral zone consideration (from CWPRS study T. R. No 5357 Feb 2016). The revised layout is shown in Fig. 2.

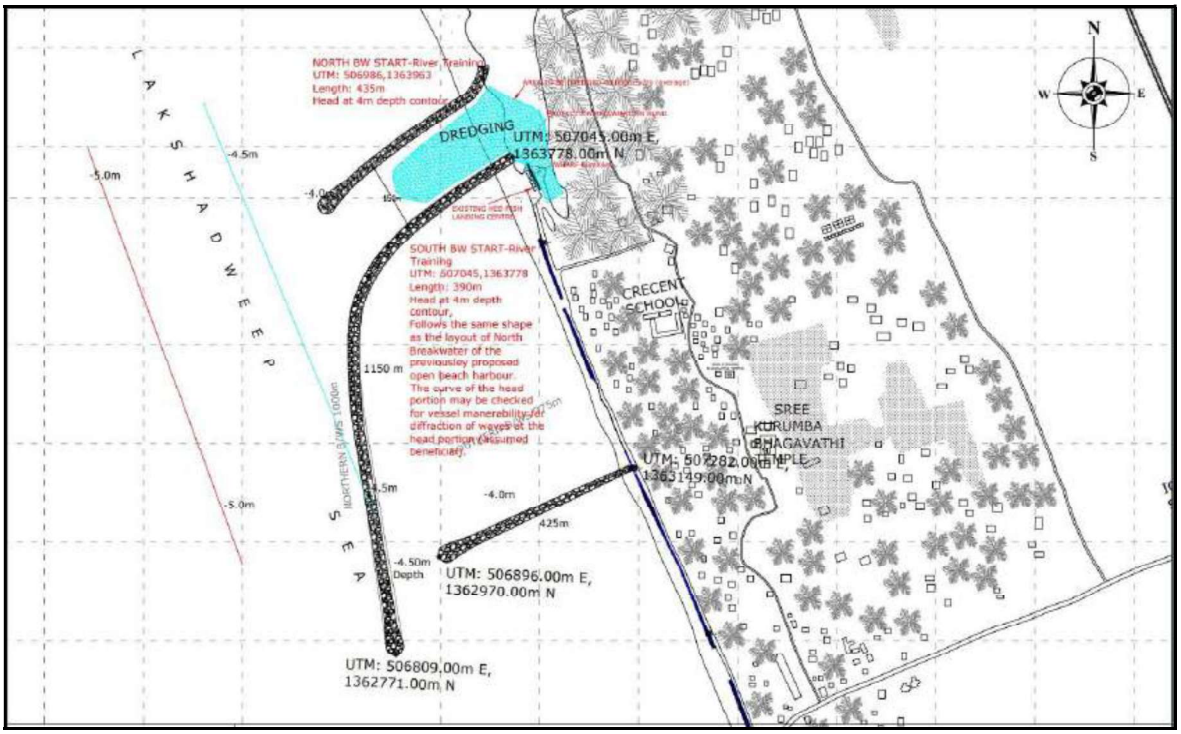


Figure 2: Proposed Layout at Ajanur

2.0 SCOPE OF STUDIES

Mathematical model studies to assess the hydrodynamics and siltation due to the proposed construction of fishing harbour are undertaken.

Following are the objectives of the present studies:

(i) To study the hydrodynamics and siltation with the existing condition.

(ii) To study the changes in hydrodynamics and siltation with the proposed condition wherein fishing harbour layout and river training work are included.

3.0 DATA ANALYSIS

The data required for the model studies are bathymetry of the area, tidal data, grain size distribution, suspended sediment concentration, river discharge, if any etc. HED, Kerala, the Project Authority (PA) has conducted field survey to collect the aforementioned data during March 2023. Earlier, PA conducted survey to collect the data in the year 2022 (1st June to 7th June). After examining the data, it was found that the data was not appropriate for numerical modelling. Hence, a re-survey for collecting the data were conducted by PA between 15th March to 20th March 2023. The data is collected both in river region (Lat:12.347, Lon 75.062) and in offshore region (Lat: 12.334 Lon: 75.0611). Henceforth, in this report these two points are called as P1 and P2 respectively as per Fig. 3. The details of the data collected are discussed below.

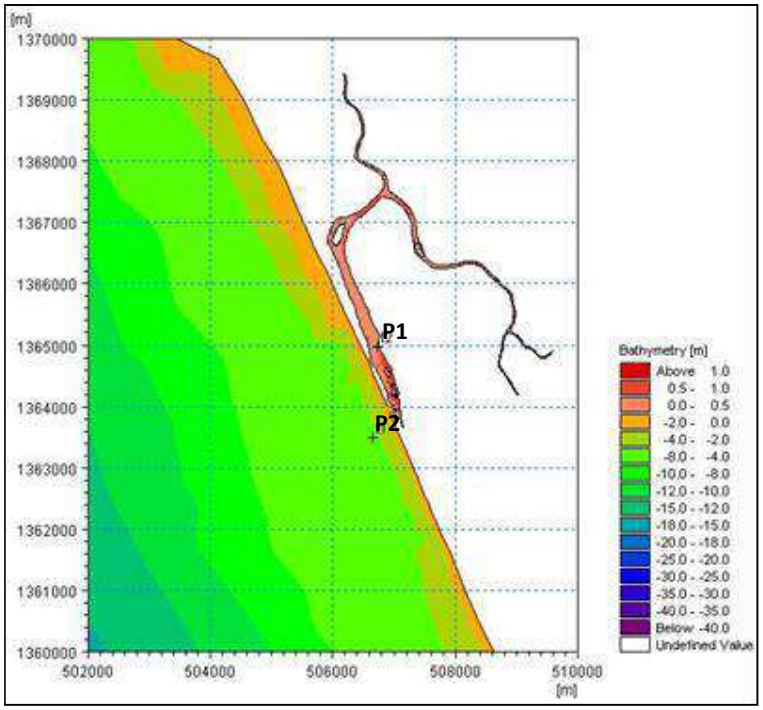


Figure 3: Field data collection points

3.1 Bathymetry

The bathymetric data for offshore shore region is obtained from C-MAP data. The nearshore bathymetry data is obtained from the hydrographic charts supplied by PA. The Acoustic Doppler Current Profiler (ADCP) of CWPRS is used to obtain the data of water level depth over the estuary and river region. The water level depth measurements are further used to estimate the bathymetry. The estimated bathymetry used in this study is shown in Fig 4.

3.2 Tides

Tidal data is collected from 15th March 2023 to 20th March 2023 at two different locations i.e., river (P1: Lat:12.347, Lon 75.062) and over sea region (P2: Lat: 12.334 Lon: 75.0611) as mentioned above. The tide data obtained at P1 and P2 w.r.t Mean Sea Level (MSL) is shown in Fig. 5. The MSL at Ajanur is 0.98m. It is observed that the spring tide tidal range (Global Tide) is about 1.30m. It is observed from the plot that tidal data at P1 is almost continuous with few missing values. However, the data at P2 is discontinuous not following usual tidal trends.

3.3 Tidal Currents

Field observed current data collected at locations P1 and P2 during March 2023 is shown in Fig 6. It is observed that the current data at both P1 and P2 shows numerous spikes at different time steps. Tide and currents data find importance in the study for calibrating the model.

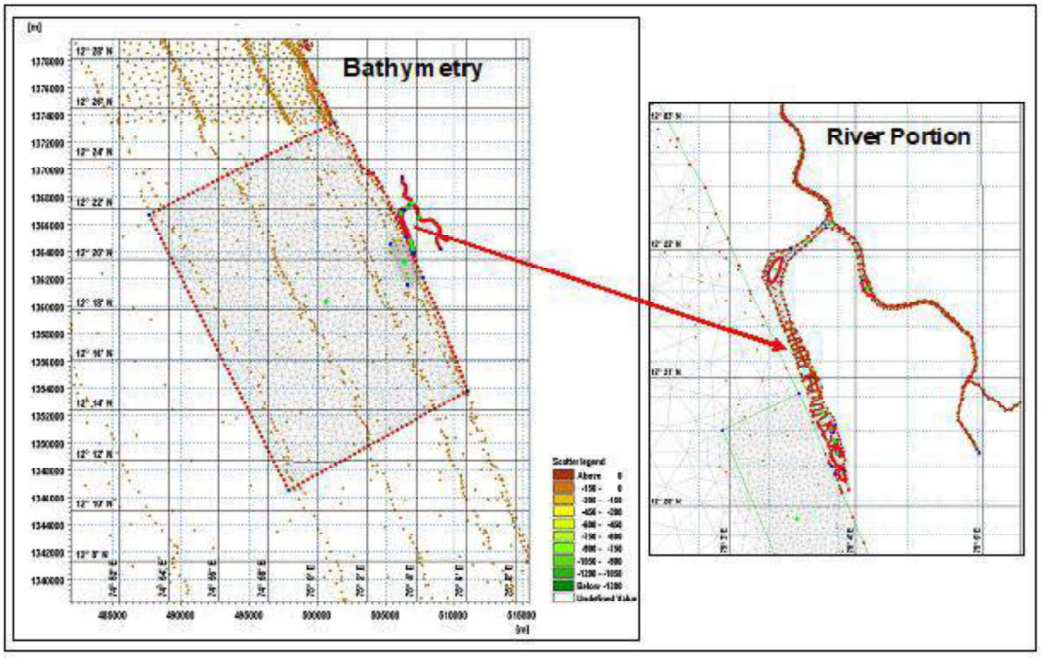


Figure 4: Bathymetry data

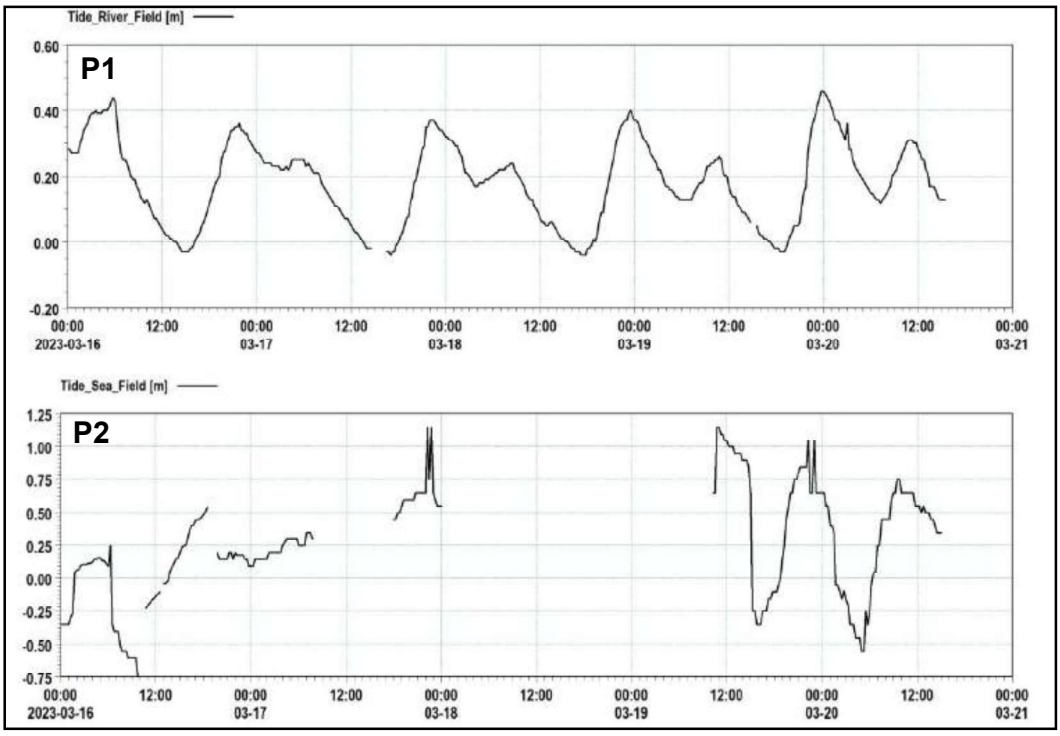


Figure 5: Observed tides at P1 and P2

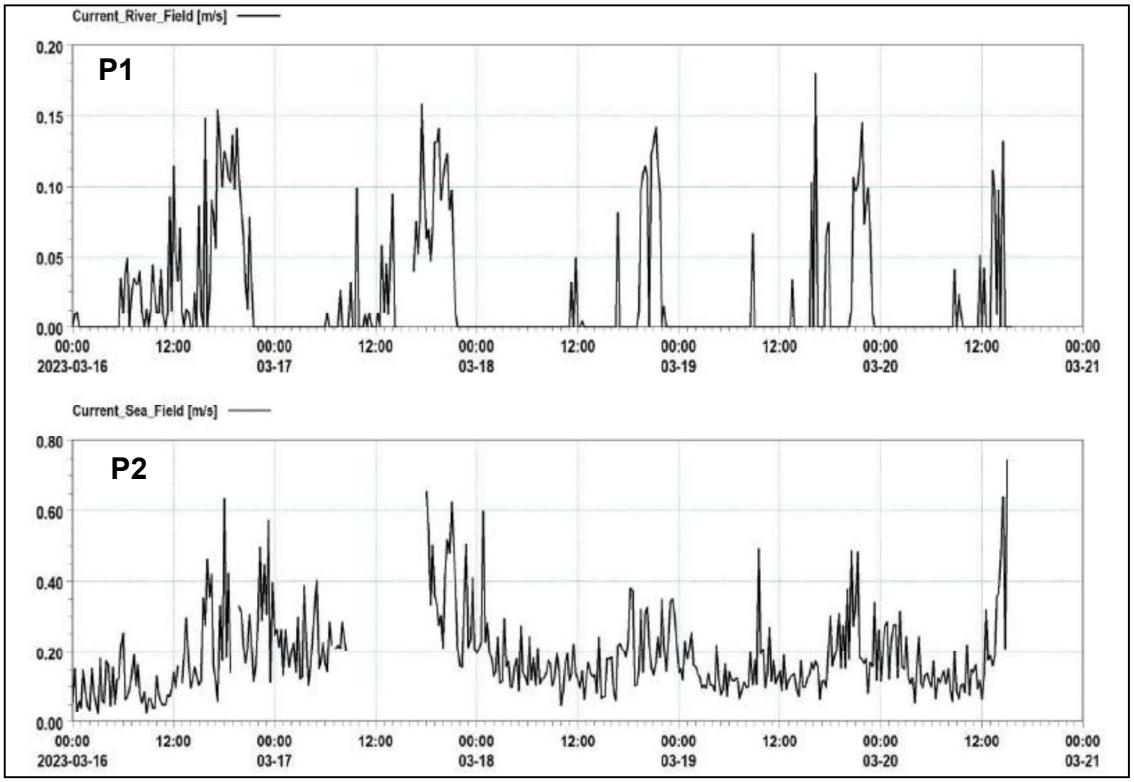


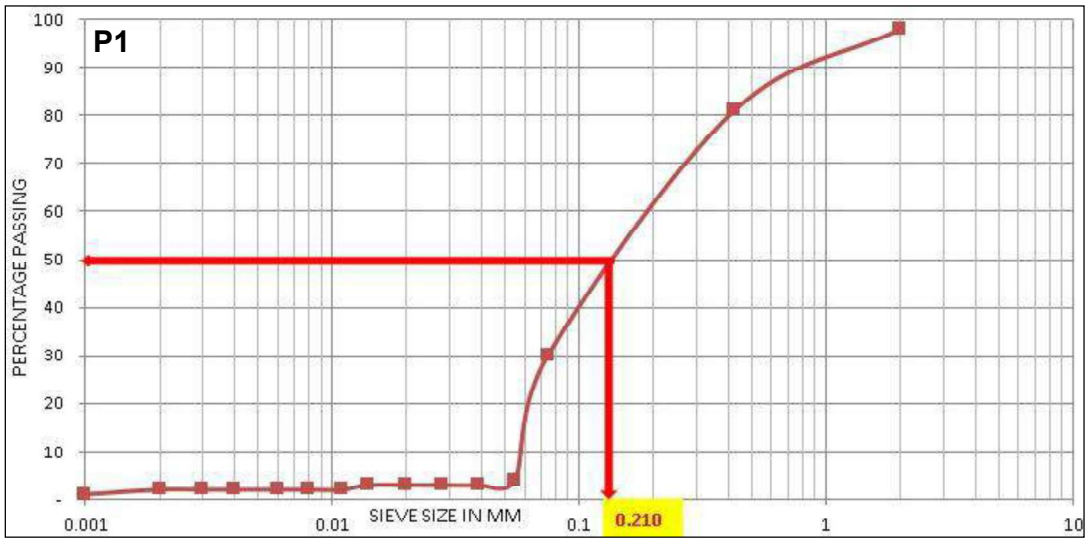
Figure 6: Observed current at P1 and P2

3.4 Sediment Data

The sediment data is collected and supplied by HED which comprised of the bed sample taken in the year 2022. The average D_{50} is 0.064mm in sea and D_{50} in river is 0.210mm.The grain size distribution at P1 and P2 is shown in Fig. 7. Water samples are collected at river and sea point (P1 and P2) during March 2023 to estimate the Suspended Sediment Concentration (SSC). From the data it is observed that SSC varies at P1 from 0.1mg/l to 0.15mg/l. Whereas, variation of SSC is between 0.05mg/l to 0.11mg/l at P2. The average suspended sediment concentration (SSC) in is 0.210mg/l and 0.08mg/l at P1 and P2 respectively. These average values of SSC are used for modelling.

3.5 Discharge Data

The river discharge is also a required parameter for calibrating the model. The river Chittari is a non-perennial river having variation in discharge during monsoon and non-monsoon seasons. As per HED, the river carries minimal discharge during monsoon and almost no discharge during the non-monsoon season. During the time period of field data collection, discharge in the river is only due to influence of tidal fluxes. The river discharge of 6 m^3/s is obtained through river ADCP observations is considered for non-monsoon season and for monsoon season, 25 m^3/s discharge is considered for modelling.



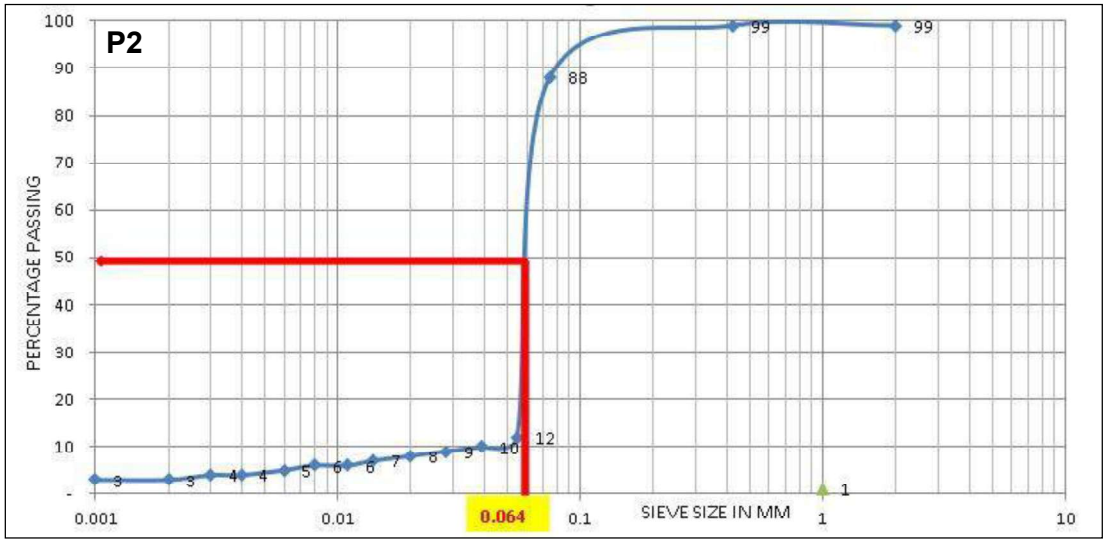


Figure 7: Grain size distribution at P1 and P2

Table 1: Details of suspended sediments concentration at P1 and P2

P1				P2			
Sample no.	Date	Time	Suspended solids in mg/l	Sample no.	Date	Time	Suspended solids in mg/l
W1	15/03/2023	7.00pm	0.12	W1	15/03/2023	10.30am	0.07
W1	16/03/2023	8.00 am	0.13	W2	15/03/2023	7.45pm	0.06
W2	16/03/2023	2.00pm	0.1	W1	16/03/2023	3.00pm	0.07
W3	16/03/2023	8.00pm	0.11	W1	17/03/2023	8.00am	0.07
W1	17/03/2023	8.00am	0.14	W2	17/03/2023	8.15pm	0.07
W2	17/03/2023	2.00pm	0.15	W3	17/03/2023	2.00pm	0.11
W3	17/03/2023	8.00pm	0.11	W4	17/03/2023	2.30pm	0.11
W1	18/03/2023	8.00am	0.13	W5	17/03/2023	8.00pm	0.09
W2	18/03/2023	2.00pm	0.11	W1	18/03/2023	8.00am	0.06
W3	18/03/2023	7.00pm	0.13	W2	18/03/2023	1.30pm	0.08
W1	19/03/2023	8.00am	0.1	W3	18/03/2023	9.00pm	0.05
W2	19/03/2023	2.00pm	0.12	W1	19/03/2023	8.00am	0.08
W3	19/03/2023	8.00pm	0.1	W2	19/03/2023	3.00pm	0.1
W1	20/03/2023	7.00am	0.11	W1	20/03/2023	8.30am	0.09
W2	20/03/2023	2.00pm	0.1	W2	20/03/2023	1.00pm	0.07

4.0 METHODOLOGY

The mathematical model studies are carried out using MIKE 21 software using the Flexible Mesh. The flexible mesh is considered as suitable for creeks with meandering coastline. The hydrodynamic studies include simulation of the flow field for the following conditions: -

1. Calibration of the model with the existing site conditions of the year 2023.
2. In the proposed condition, the layout as shown in Fig. 2 is studied for assessment of changes in the hydrodynamics and sedimentation.

The model run to evaluate hydrodynamics would be calibrated with the observed field data along with wave induced currents (radiation stresses) from wave model studies. The calibrated model will be used to predict the changes in the flow pattern for the proposed condition. The results of the above hydrodynamic studies are used as basic input for the sediment transport studies.

Model studies are carried out by coupling the flow models with sedimentation models to predict the evolving changes in sedimentation pattern. The results of these studies show the spatially varying pattern of siltation and erosion. The simulation of hydrodynamics and sedimentation (for existing and proposed condition) is separately performed for monsoon and non-monsoon seasons. The comprehensive detail of the hydrodynamics, wave and siltation studies for both existing and proposed condition is useful information for the coastal population and also the policy makers.

5.0 DESCRIPTION OF MODULES OF MIKE 21 FM

The 2-dimensional hydrodynamic model MIKE 21 HD, Flexible Mesh is used for simulating the flow field in the model domain and MIKE 21 MT for the sediment transport studies in the existing and the proposed scenario under prevailing tidal and wave conditions. The brief description of scientific background of MIKE 21 HD and MIKE 21 MT is given below.

5.1 MIKE-21 HD MODULE:

For any major developments in coastal areas, it is necessary to know dynamics of the water body in terms of velocity and water level fluctuations beforehand. The appropriate governing equations for studying water movement in coastal areas are the two-dimensional shallow water equations. These shallow water equations are obtained by vertically integrating the 3-Dimensional incompressible Reynold's averaged Navier- Stokes equations of motion over depth $h = \eta + d$ with the following simplified assumptions.

- The flow is incompressible,
- The flow is well mixed (no variation in density)
- Vertical accelerations are negligible,
- Bed stress can be modeled.

$$\frac{\partial h}{\partial t} + \frac{\partial h\bar{u}}{\partial x} + \frac{\partial h\bar{v}}{\partial y} = hS \qquad (1)$$

$$\frac{\partial h\bar{u}}{\partial t} + \frac{\partial h\bar{u}^2}{\partial x} + \frac{\partial h\overline{vu}}{\partial y} = f\bar{v}h - gh\frac{\partial \eta}{\partial x} - \frac{h}{\rho_0}\frac{\partial p_a}{\partial x} - \frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial x} + \frac{\tau_{sx}}{\rho_0} - \frac{\tau_{bx}}{\rho_0} -$$

$$\frac{1}{\rho_0}\left(\frac{\partial s_{xx}}{\partial x} + \frac{\partial s_{xy}}{\partial y}\right) + \frac{\partial}{\partial x}(hT_{xx}) + \frac{\partial}{\partial y}(hT_{xy}) + hu_sS \qquad (2)$$

$$\frac{\partial h\bar{v}}{\partial t} + \frac{\partial h\bar{v}^2}{\partial x} + \frac{\partial h\overline{uv}}{\partial y} = f\bar{u}h - gh\frac{\partial \eta}{\partial y} - \frac{h}{\rho_0}\frac{\partial p_a}{\partial y} - \frac{gh^2}{2\rho_0}\frac{\partial \rho}{\partial y} + \frac{\tau_{xy}}{\rho_0} - \frac{\tau_{by}}{\rho_0} -$$
$$\frac{1}{\rho_0}\left(\frac{\partial s_{yx}}{\partial x} + \frac{\partial s_{yy}}{\partial y}\right) + \frac{\partial}{\partial x}(hT_{xy}) + \frac{\partial}{\partial y}(hT_{yy}) + hv_sS \qquad (3)$$

The over bar indicates a depth average value for example, $\bar{u}$ and $\bar{v}$ are the depth-averaged velocities defined by

$$h\bar{u} = \int_{-d}^{n} u dz\,, \qquad h\bar{v} = \int_{-d}^{n} v dz$$

The lateral stresses T_{ij} include viscous friction, turbulent friction and differential advection. They are estimated using an eddy viscosity formulation based on the depth average velocity gradients.

$$T_{xx} = 2A\frac{\partial \bar{u}}{\partial x} \qquad T_{xy} = A\left(\frac{\partial \bar{u}}{\partial y} + \frac{\partial \bar{v}}{\partial x}\right) \qquad T_{yy} = 2A\frac{\partial \bar{v}}{\partial y}$$

The following symbols are used in the equations:

t	:	Time
x and y	:	Cartesian co-ordinates
$h = \eta + d$	:	Total water depth
d	:	Still water depth
S_{xx}, S_{xy}, S_{yy}	:	Components of radiation stresses
$\tau_{xx}, \tau_{xy}, \tau_{yy}$	:	Shear stress components
ρ	:	Density of water
$\bar{u}\bar{v}$	:	Depth averaged velocities
η	:	Surface Elevation
g	:	acceleration due to gravity (m/s^2)
f	:	wind friction factor related to Coriolis parameter
p_a	:	Atmospheric pressure
ρ_0	:	Density of water
S	:	Magnitude of discharge due to point sources
u_s, v_s	:	velocities at point sources
$f = 2\Omega sin\Phi$	:	Coriolis parameter (Ω is the angular rate of revolution and φ the geographic Latitude)
A	:	Horizontal eddy viscosity

The governing equations are solved by using an element-centered finite volume method. The spatial domain is discretised into non-overlapping elements, which can be either triangular or quadrilateral. The time integration can be done by using first order explicit Euler method (referred to as the lower temporal order scheme) or by using second order Runge Kutta method (referred to as the higher temporal order scheme).

5.2 MIKE-21 MT MODULE

The sediment transport studies were carried out using MIKE 21 MT model. This model simultaneously solves hydrodynamic and sediment transport equations. The calibration of sediment transport model is difficult because morphological changes are too slow and temporal bed changes are too variable to measure anything significant for comparison. The sediment fluxes at various locations may differ and the following factors contribute for these variations:

- Unsteadiness of flow,
- Mixtures of sediment in suspension,
- Variability of supply of mobile sediment on the bed,
- Presence of sandy (non-cohesive) sediment,
- Omission of depth variation,
- Effect of wave stirring.

The erosion, transport and deposition of silt, mud and clay particles under action of currents and waves can be best described by the multi-layers mode of the mud transport module of MIKE 21. The sediment transport module is dynamically coupled with the 2-dimensional hydrodynamic module, MIKE 21 HD. The module solves the primitive equations in two dimensions using finite difference methods by Alternating Direction Implicit technique and the Double Sweep algorithm. Following are the relationships used in the module.

The sediment transport formulations are built into the advection-dispersion module, MIKE 21 AD, which solves advection-dispersion equation:

$$\frac{\partial c}{\partial t}+u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}=\frac{1}{h}\frac{\partial}{\partial x}\left(hD_x\frac{\partial c}{\partial x}\right)+\frac{1}{h}\frac{\partial}{\partial y}\left(hD_y\frac{\partial c}{\partial y}\right)+Q_L C_L\frac{1}{h}-S \qquad (4)$$

The following symbols are used in the equation:

c	:	compound concentration (arbitrary units)
u,v	:	horizontal velocity components in x, y directions (m/s)
h	:	water depth (m)
Dx,Dy	:	dispersion coefficients in the x,y directions (m2/s)
S	:	accretion/erosion term (kg/m3/s)
QL	:	source discharge per unit horizontal area (m2/s/m2)
CL	:	concentration of source discharge (kg/m3)

The advection-dispersion equation is solved using an explicit, third-order finite difference scheme, and known as the ULTIMATE scheme.

6.0 MODEL STUDIES

The MIKE 21 HD module is used to study the hydrodynamics. For studying the sedimentation, MIKE 21 MT module is used. These modules are used for the existing and proposed layouts. The details of MIKE 21 HD and MIKE 21 MT modules used in this study are discussed below.

6.1 Computational Model

The spatial extent of computational model considered for model simulations is 16km (cross-shore) X 22km (along the shore). The computation model with its offshore and onshore boundaries is shown in Fig. 8. The Chittari river discharging into the ocean is considered to a certain extent in the computation model as shown in Fig. 8.

All oceanographic features of the study region in existing condition are incorporated in the computational model. The complete study area was discretised into computational unstructured mesh. The spatial resolution of the mesh is finer along the area of development (harbour area). Finer mesh resolution is adopted near harbour area in order to capture the variation in near shore tide and currents more accurately. The mesh resolution is coarser along the offshore boundary. The developed mesh showing the fine and coarser resolution in the computational model is shown in Fig. 9.

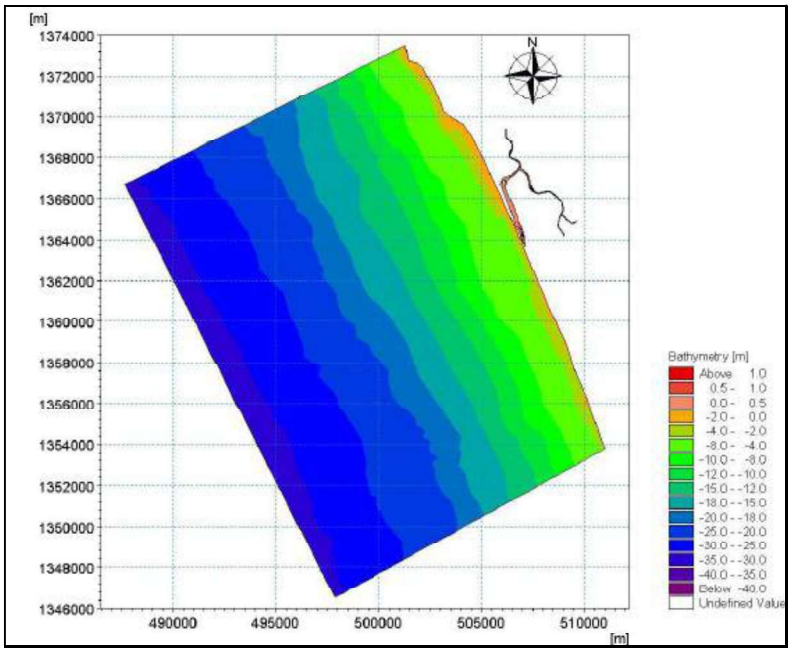


Figure 8: Computational model

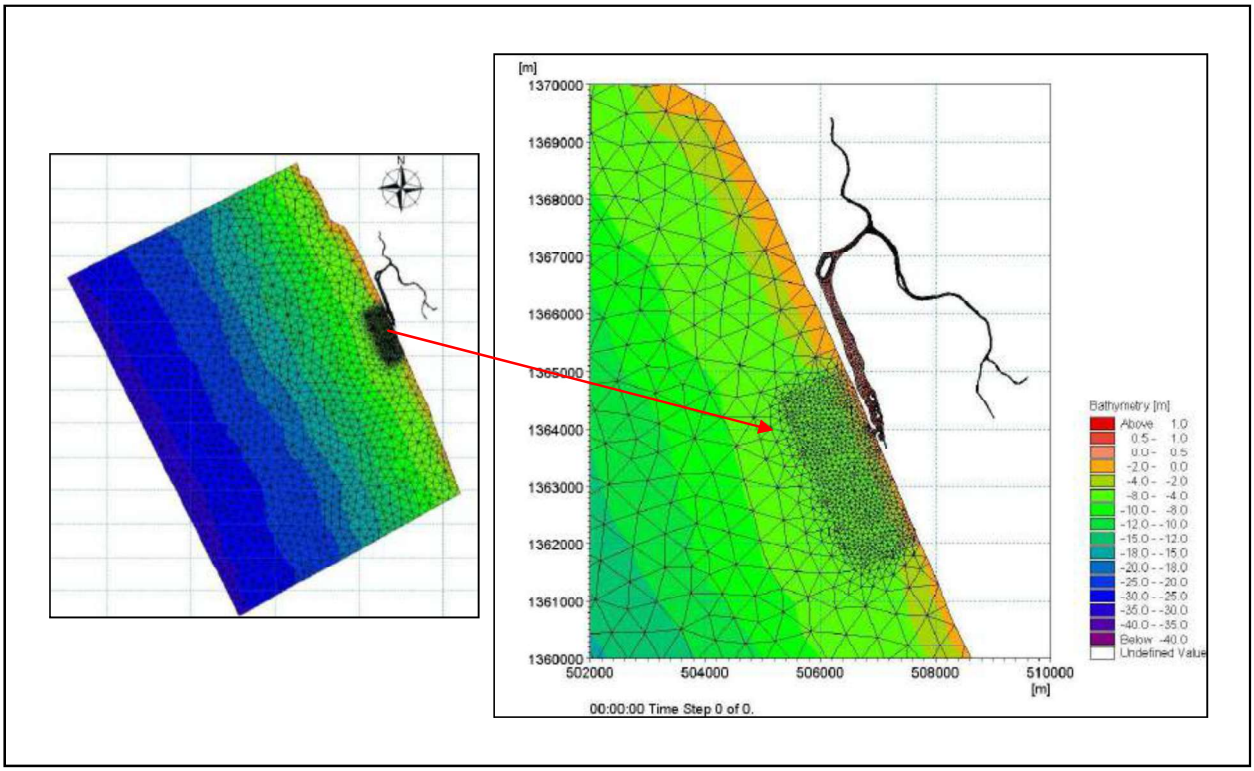


Figure 9: Computational mesh showing variable mesh resolution

6.2 Simulation of Flow Field – Existing condition- non-monsoon and monsoon seasons

Initially, flow field are modelled for the existing conditions for both non-monsoon and monsoon seasons. Defining boundary condition is essential for modelling the flow field. There are three offshore boundaries and one land boundary. The boundary tides are defined along these three offshore boundaries. The boundary tides obtained from MIKE 21 Global tidal model is used to define the boundary condition with phase lag. Further, discharge along the Chittari river is also given as another boundary condition. As the flow is assumed to be parallel to the contours along the western boundary, no-cross flux was considered in the west boundary in the open sea. Radiation stresses are also considered in the simulation to take into account the effect of wave induced currents. With these given forcings, MIKE 21 HD module is used to model the variation in tides and currents for a period of 15 days in non-monsoon (March 2023) and monsoon (July 2023) separately. The changes in flow fields are estimated every 30 minutes. Typical velocity vector plots during different phase of tides obtained during non-monsoon and monsoon seasons are shown from Fig. 10 to Fig. 13.

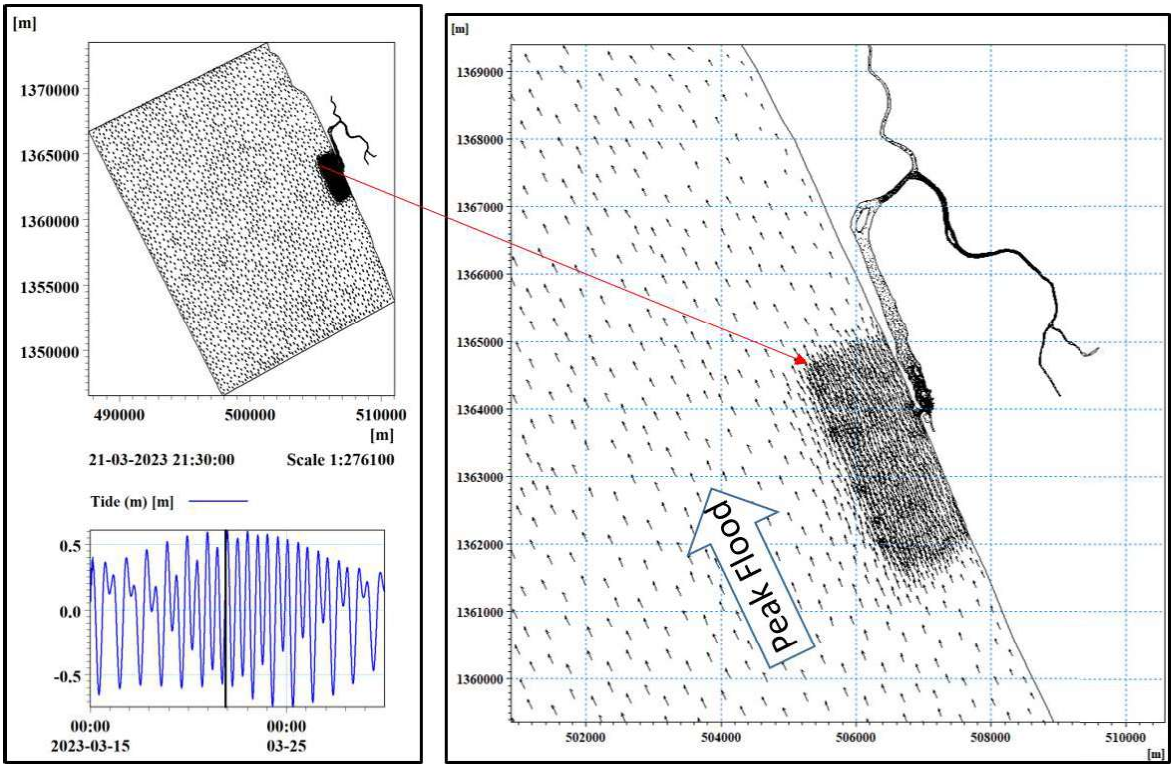


Figure 10: Flow field during peak flood-Non-monsoon season (Existing)

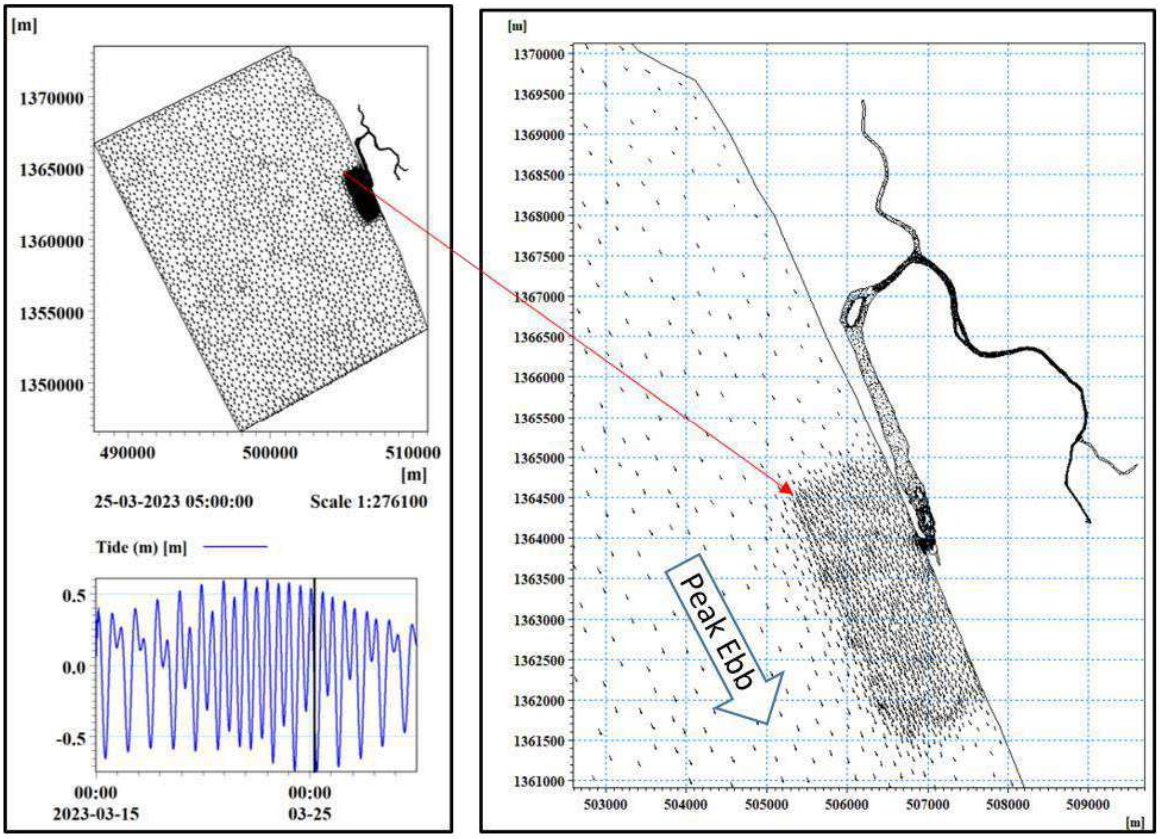


Figure 11: Flow field during peak ebb -Non-monsoon season (Existing)

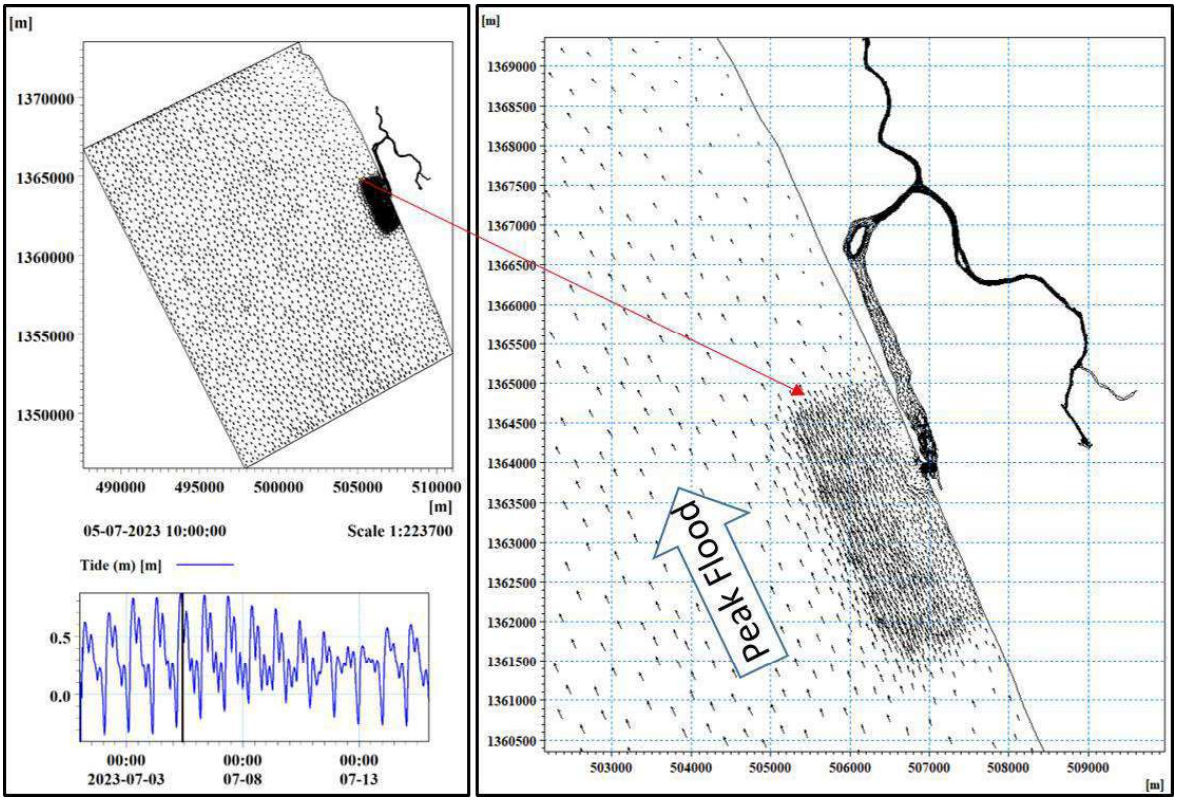


Figure 12: Flow field during peak flood- Monsoon season (Existing)

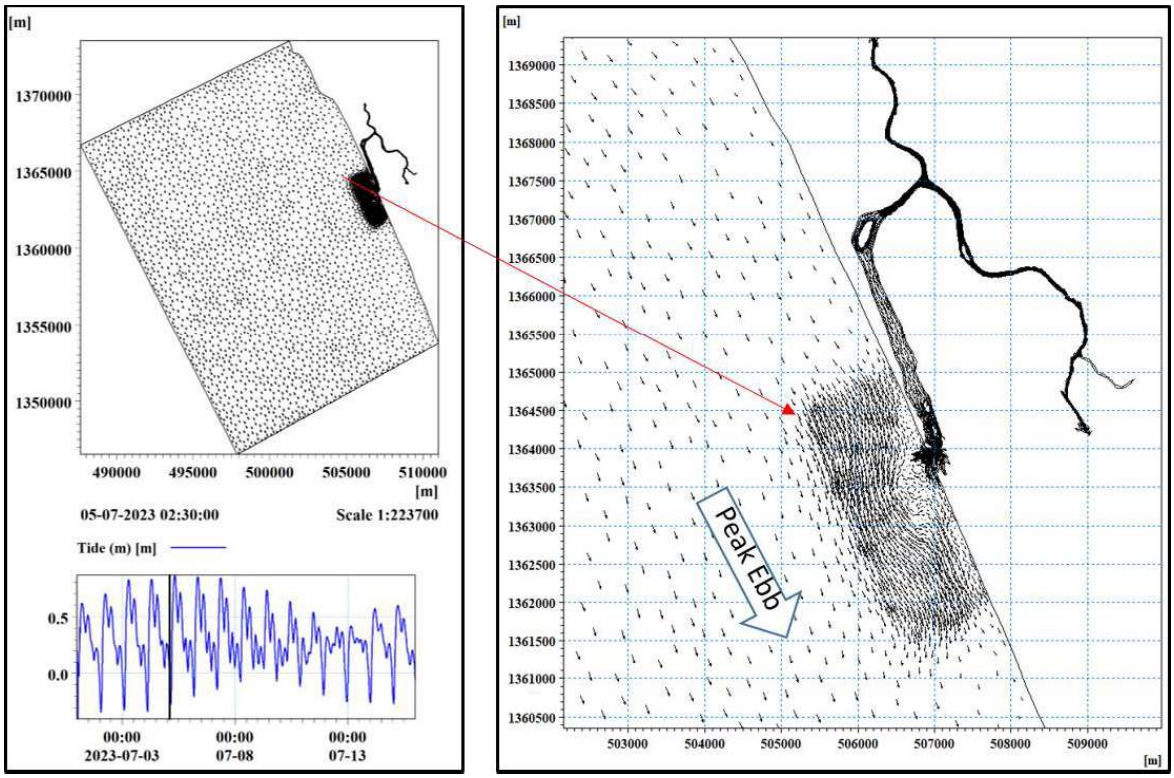


Figure 13: Flow field during peak ebb- Monsoon season (Existing)

The length of the vector gives magnitude of the current while the arrowhead shows the direction of flow. During peak flood, flow follows natural contour parallel to the coastal. The observed data of tides and current are provided at two points (P1 and P2) in the study area by the HED. Point P1 and Point P2 is located along the river and sea side of the computational domain respectively. The details of geographical location of P1 and P2 is discussed above in section 3. These two points are used for the purpose of comparison of modelled tides and currents against the observed values. The observed data of tides and currents at P1 and P2 are obtained during non-monsoon season only. The comparison of computed tides against the field values during non-monsoon season is shown in Fig. 14.

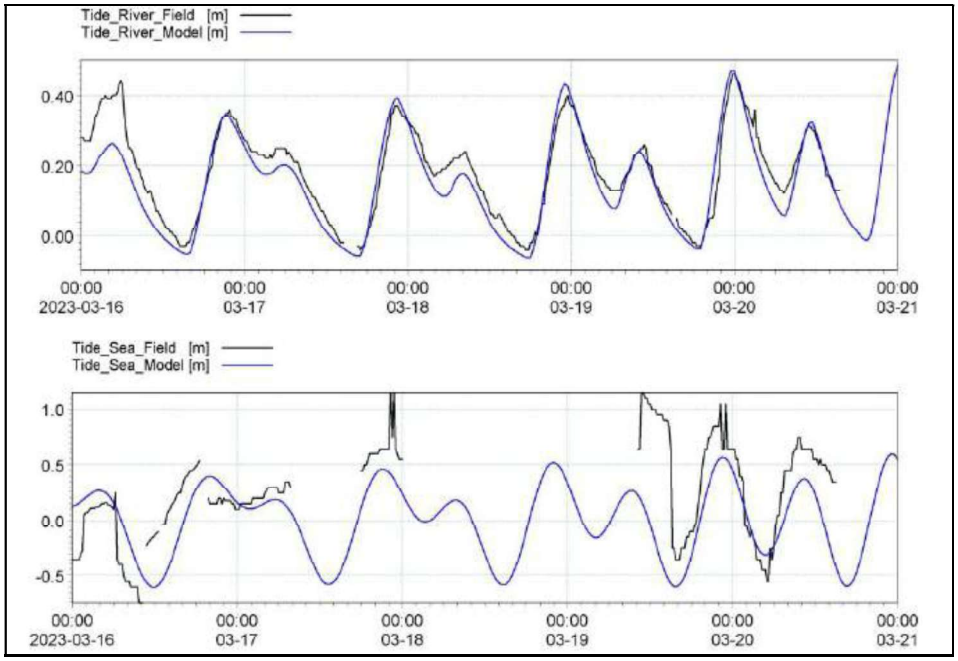


Figure 14: Comparison of tides (Field Vs Computed)

From the Fig.14, it is observed that there is good correspondence between the computed and field values of tides at the point P1. The good correspondence at P1 signifies the efficacy of model calibration. Due to the inherent ambiguity of the field current data at P1 and P2 provided by the PA, it is not possible to compare the computed values of currents at P1 and P2 against the field data. However, modelling results of currents shows that peak values of currents are captured more accurately by the model. Hence, there is good correspondence of computed peak current with the field peak currents. The peak of field current is 0.14m/s and peak of computed current obtained is 0.17m/s at P1. Similarly, at P2 peak of field current is 0.40m/s whereas peak of obtained computed current is 0.39m/s. The littoral drift and sediment pattern studies for the existing condition is discussed below

6.3 Littoral Drift Studies

Littoral drift studies are necessary for mapping the littoral distribution and changes in shoreline at the proposed location of fishing harbour. The littoral drift at this study area was carried out by CWPRS in the year 2016. The simulation results of the littoral studies were already reported vide Technical Report: - T.R. No. 5357 of 2016. The study reveal that annual southward and northward transports are 0.531Mm^3 and 0.118Mm^3 respectively with the net and gross transports being 0.413Mm^3 and 0.649Mm^3 respectively. Other findings of the study reveal that shoreline evolution in 10 years period will result in accretion on the northern side (68m in cross shore direction) and southern side (40m in cross-shore direction) of the proposed northern and southern breakwater respectively. This accretion and erosion is expected to extend further upto 2500m and 1500m towards along the shore towards north and south direction respectively. The shoreline evolution over the years for accretion and erosion is shown in Fig.15. Taking into consideration the influential role of silt and clay (mud) on sedimentation, in the present study, Mud Transport (MT) is modelled using MIKE 21 MT for identifying the spatially varying zones of sedimentation.

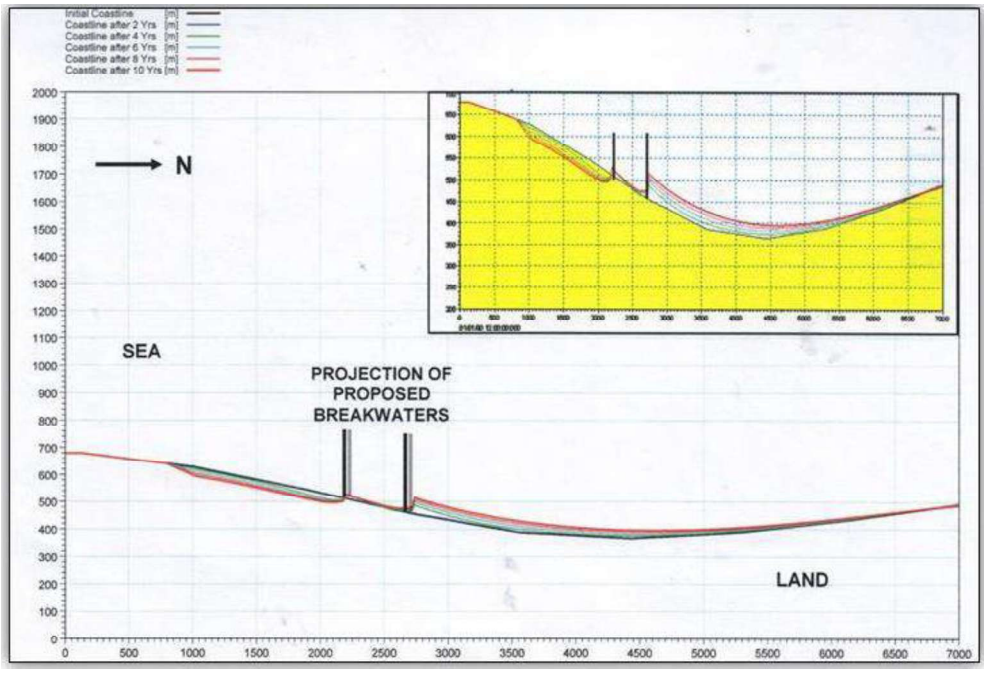


Figure 15: Shoreline evolution after 2nd,4th ,6th,8th and 10th year

6.4 Sedimentation Pattern - Existing Condition-non-monsoon and monsoon seasons

The sedimentation studies were carried out for the existing conditions for both non-monsoon and monsoon seasons using MIKE21 MT module. The results of hydrodynamic studies is one of the important inputs for sedimentation modelling using MIKE21 MT . Other inputs required are SSC and bed sample data in the study area. The data of SSC and bed sample are given by

HED for non-monsoon season. For monsoon season 50% increased SSC fraction of non-monsoon season is assumed to be adopted as input for sedimentation modelling. Using these inputs in the MIKE 21 MT model, sedimentation studies were carried out for the existing condition for a period of one month. The sedimentation patterns during non-monsoon and monsoon seasons are shown in Fig. 16 and Fig. 17 respectively. During monsoon period with the elevated discharge of Chittari River, flushing out of sediments deposited during non-monsoon period is observed. The estimated deposition (maximum) of about 0.1m in a year over the computational domain is obtained. The annual sedimentation estimated at the river mouth is about 0.021m for the existing condition.

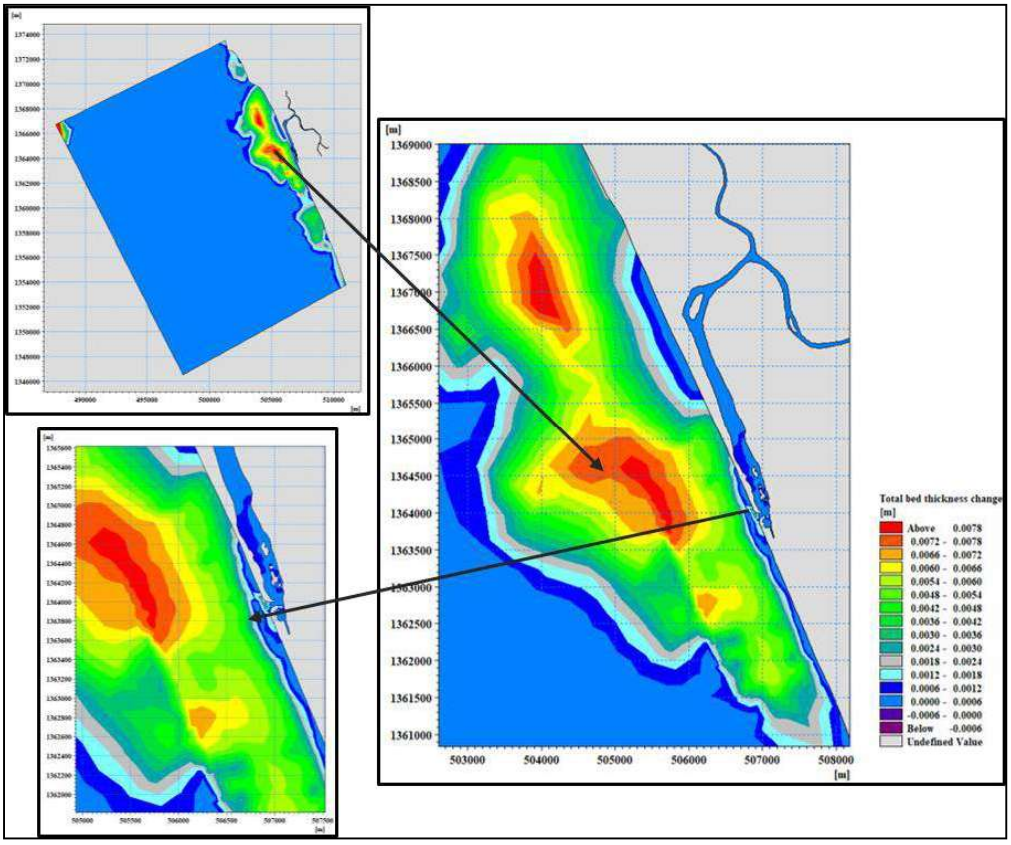


Figure 16: Sedimentation pattern during Non-monsoon season (Existing)

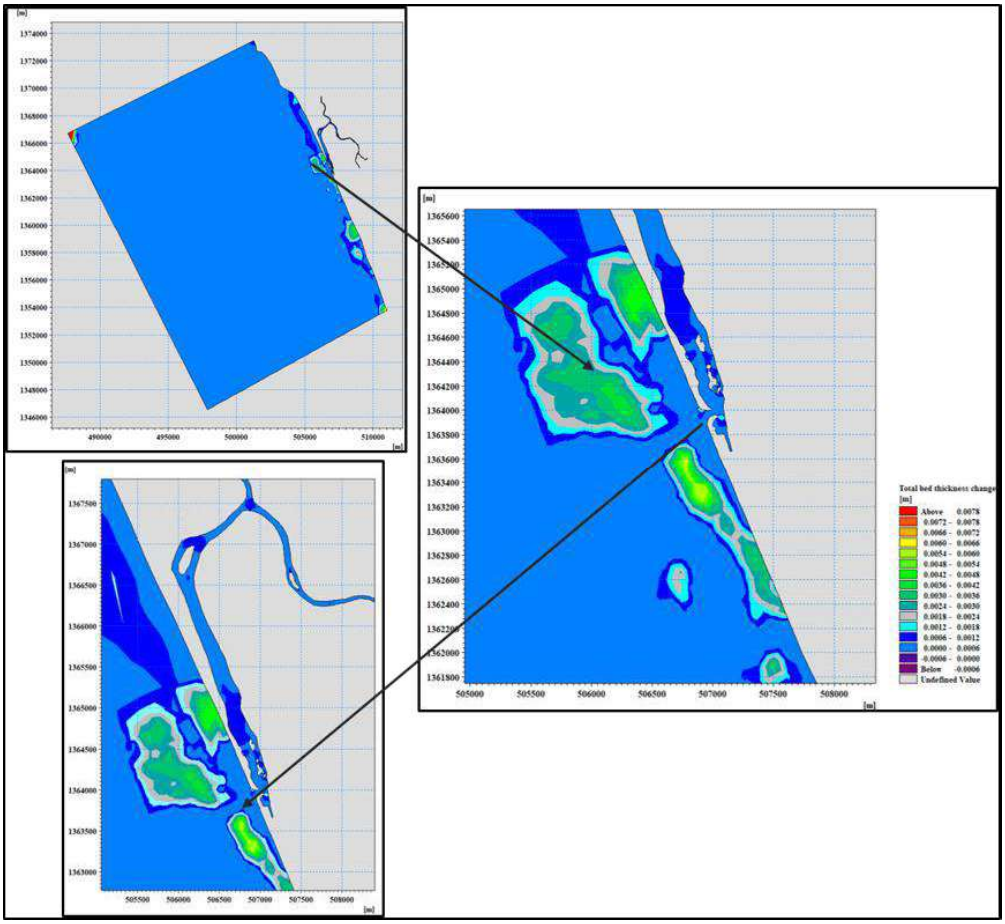


Figure 17: Sedimentation pattern during Monsoon season (Existing)

6.5 Simulation of Flow Field - Proposed Condition-non-monsoon and monsoon seasons

The calibrated model setup of existing condition was re-established by incorporating the features of the proposed layout. The layout consists of 1150m long north breakwater, 425m long south breakwater, 435m breakwater as a river training work & dredging (-2m) inside the approach channel nearer to the Chittari river mouth and suitable dredging along the river. The layout also consists of dredging of -4m inside the proposed fishing harbour. The bathymetry after re-establishing the proposed layout is shown in Fig. 18.

The computation domain with the unstructured mesh developed for the proposed layout is shown in Fig. 18. The mesh resolution considerations are the same as discussed in the section 6.1.

The flow is modelled during non-monsoon and monsoon seasons following the similar procedure and boundary condition constraints as adopted for simulating the flow conditions for the existing conditions. MIKE 21 HD module is again simulated to get the outputs of tides and currents for the proposed layout.

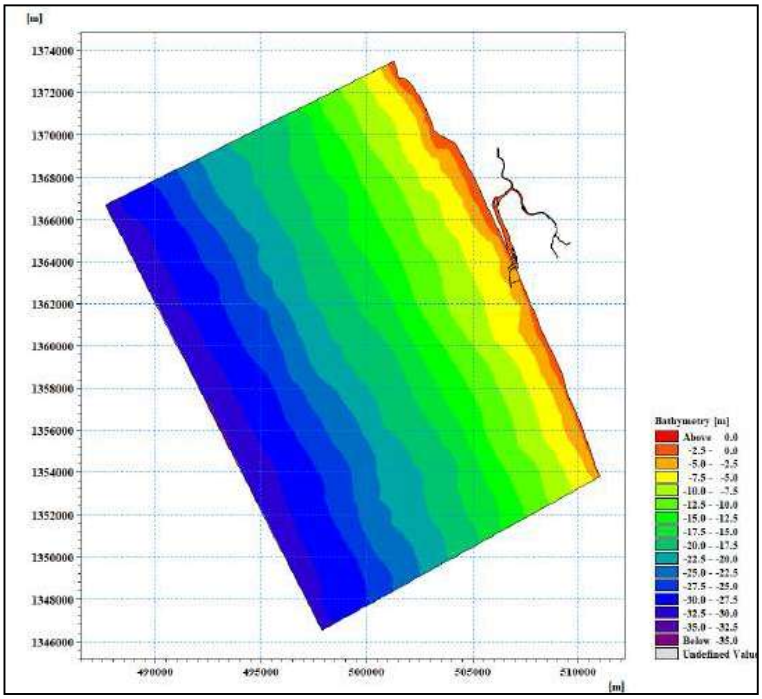


Figure 18: Bathymetry with proposed layout

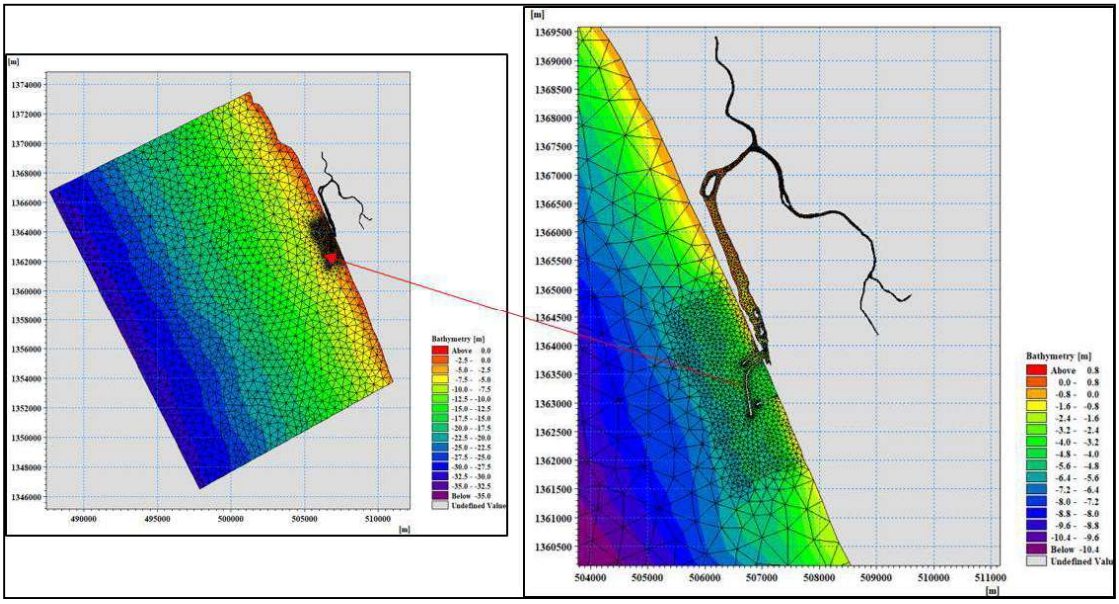


Figure 19: Computational domain for proposed layout

The flow fields along the model domain obtained for non-monsoon and monsoon seasons during peak flooding and ebbing tidal phases are shown from Fig. 20 to Fig. 23. During non-monsoon season, it is observed from the flow fields that circulation is formed near south breakwater during ebbing phase of tide. However, during monsoon season, circulation is formed near south breakwater (during flooding and ebbing phase of tide). In addition, during flooding phase, circulation is formed at 2 other locations (near north breakwater and entrance of river mouth) also. Though eddies formed around the circulation are weak, its intensity may

change according to changes in local climate. Furthermore, four points t1, t2, t3 and t4 called as monitoring stations are considered for assessment of changes in currents after construction of proposed layout. The locations of these four monitoring stations are shown in Fig. 24.

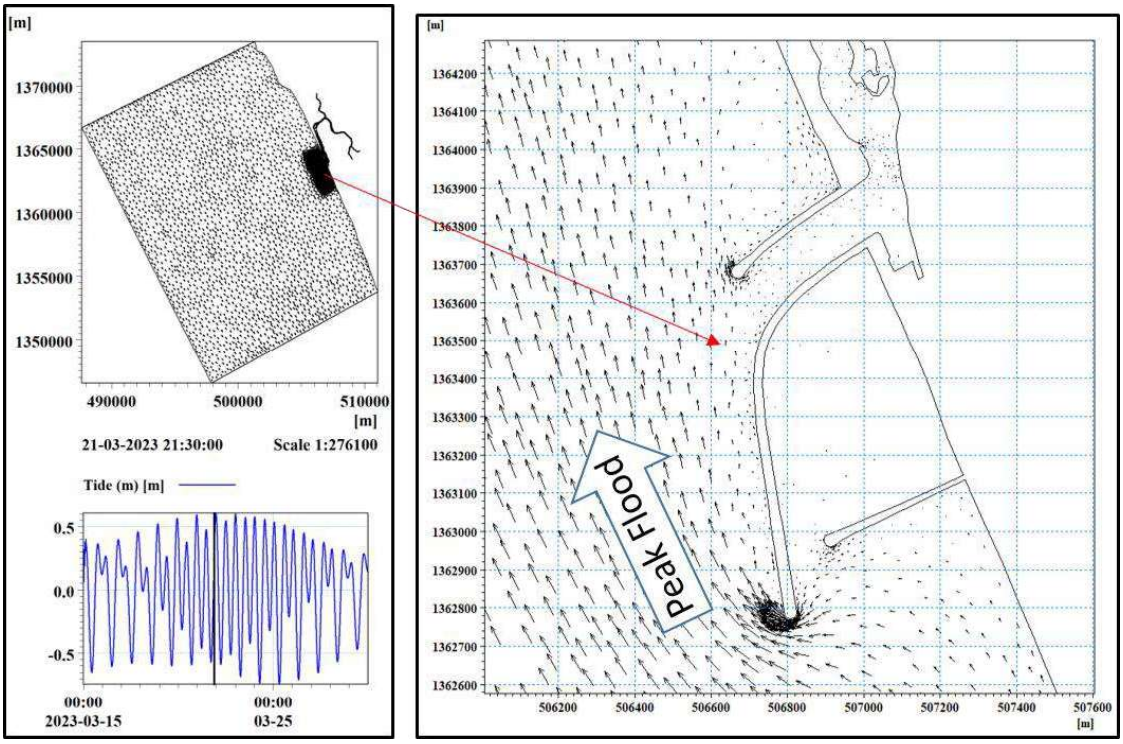


Figure 20: Flow field during peak flood-Non-monsoon season (Proposed condition)

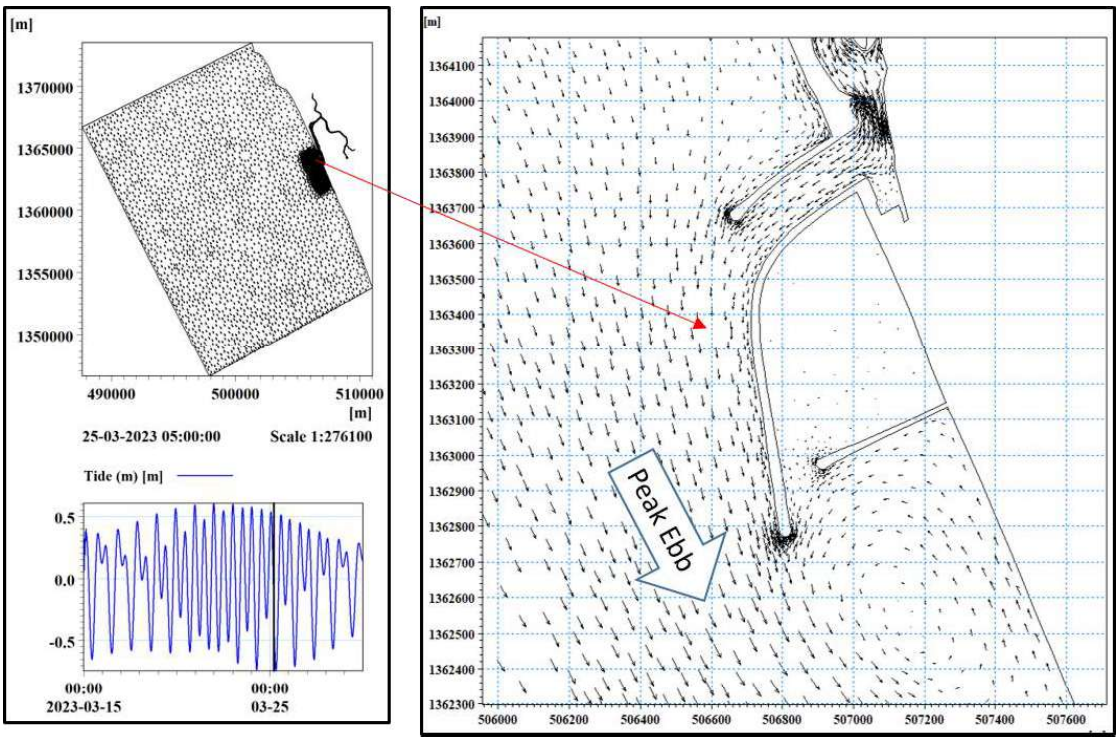


Figure 21: Flow field during peak ebb -Non-monsoon season (Proposed condition)

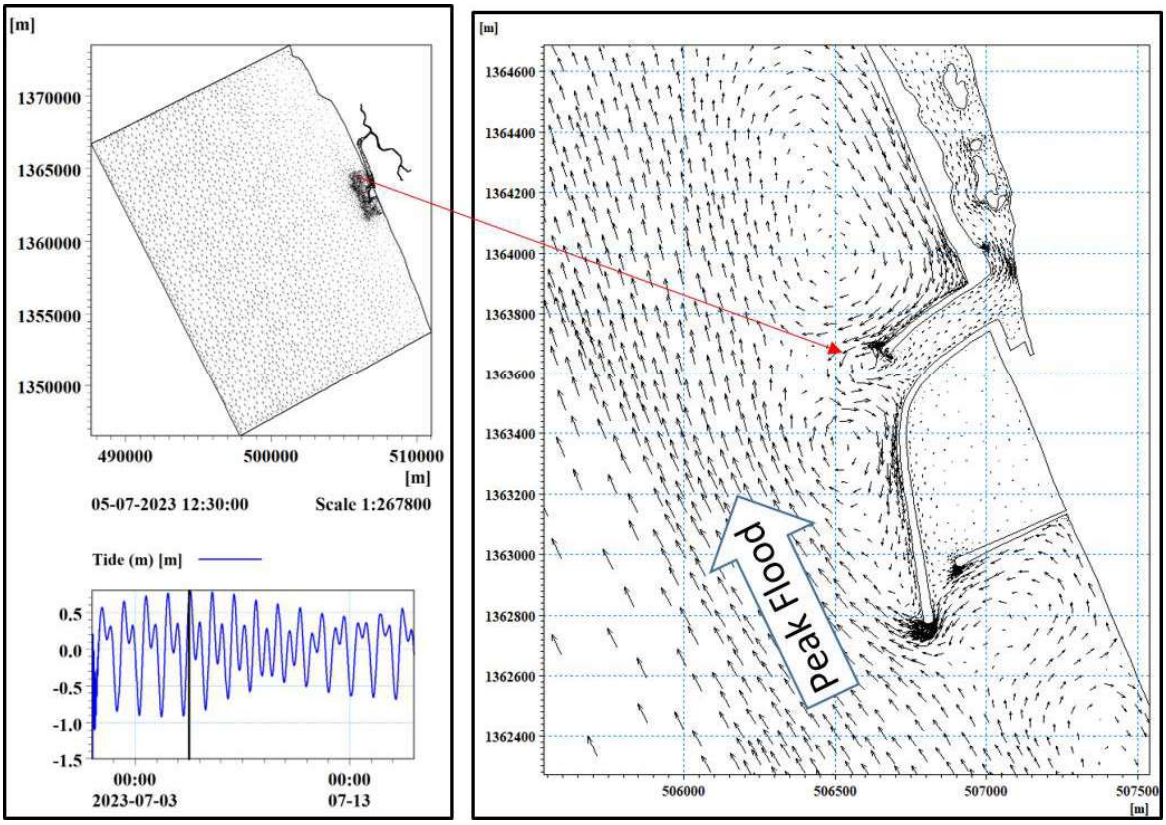


Figure 22: Flow field during peak flood- Monsoon season (Proposed condition)

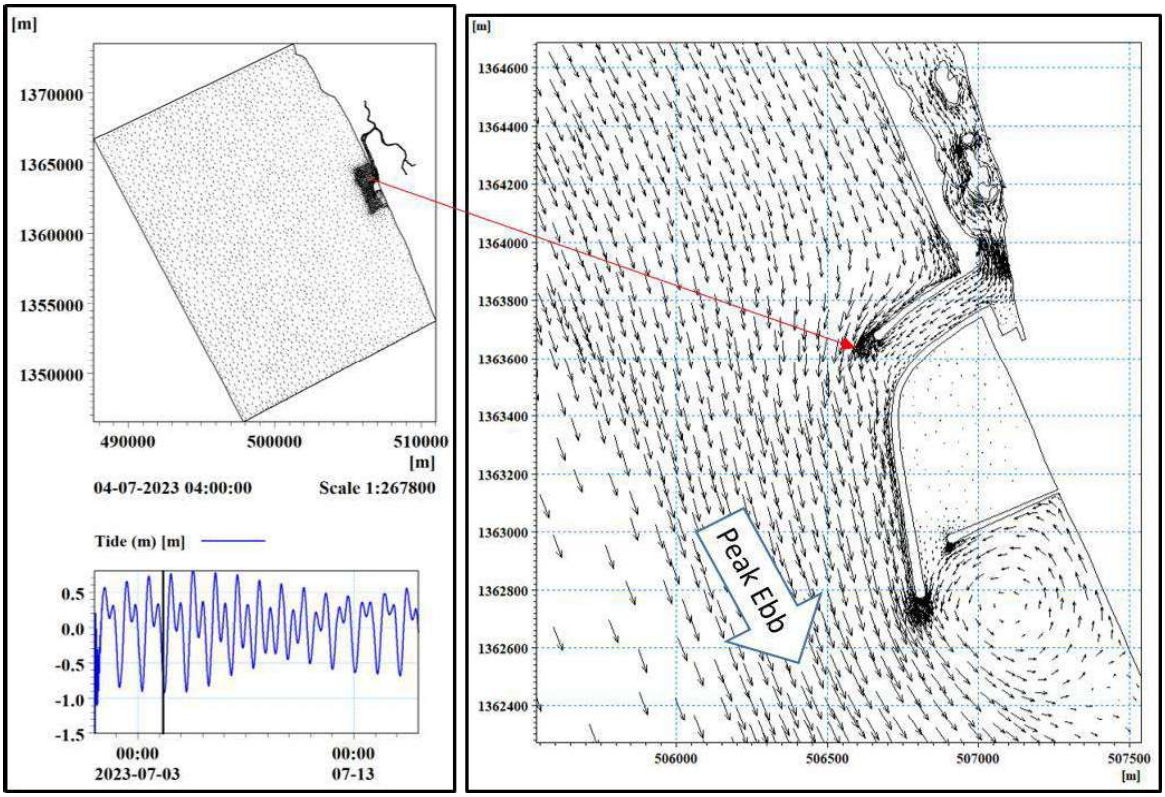


Figure 23: Flow field during peak ebb- Monsoon season (Proposed condition)

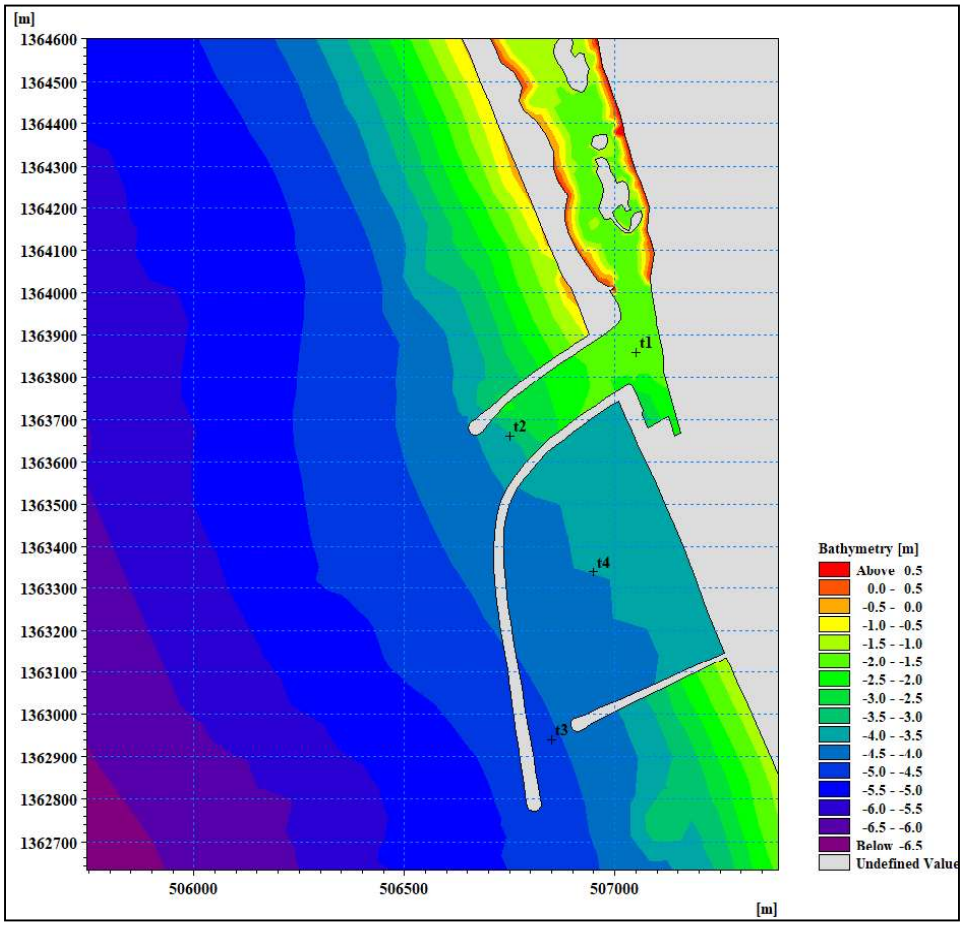


Figure 24: Details of proposed layout with monitoring stations

The computed currents during non-monsoon and monsoon period at all monitoring stations obtained for the proposed layout is compared against the computed currents at corresponding points for the existing condition. The comparison is shown in Fig. 25 and Fig. 26. It is observed from Fig. 25 and Fig. 26 that both during non-monsoon and monsoon season only at the monitoring station t1, there is increase in magnitude (from 0.007 m/s to 0.1m/s during non-monsoon and from 0.015m/s to 0.3m/s during monsoon season) of currents after the proposed construction work. At t2, t3 and t4, the magnitude of currents is significantly reduced after the proposed development. During non-monsoon season, the peak modelled currents at t2, t3 and t4 for existing condition are 0.43m/s, 0.38 m/s and 0.39 m/s respectively. After the proposed development the currents at these three monitoring stations are reduced to 0.11m/s, 0.06m/s and 0.008m/s. However, during monsoon season, at t2, t3 and t4 for existing conditions, the peak modelled currents are 0.55m/s, 0.46m/s and 0.49m/s respectively. The currents at t2, t3 and t4 are reduced to 0.21m/s, 0.11m/s and 0.003m/s after proposed development during monsoon season.

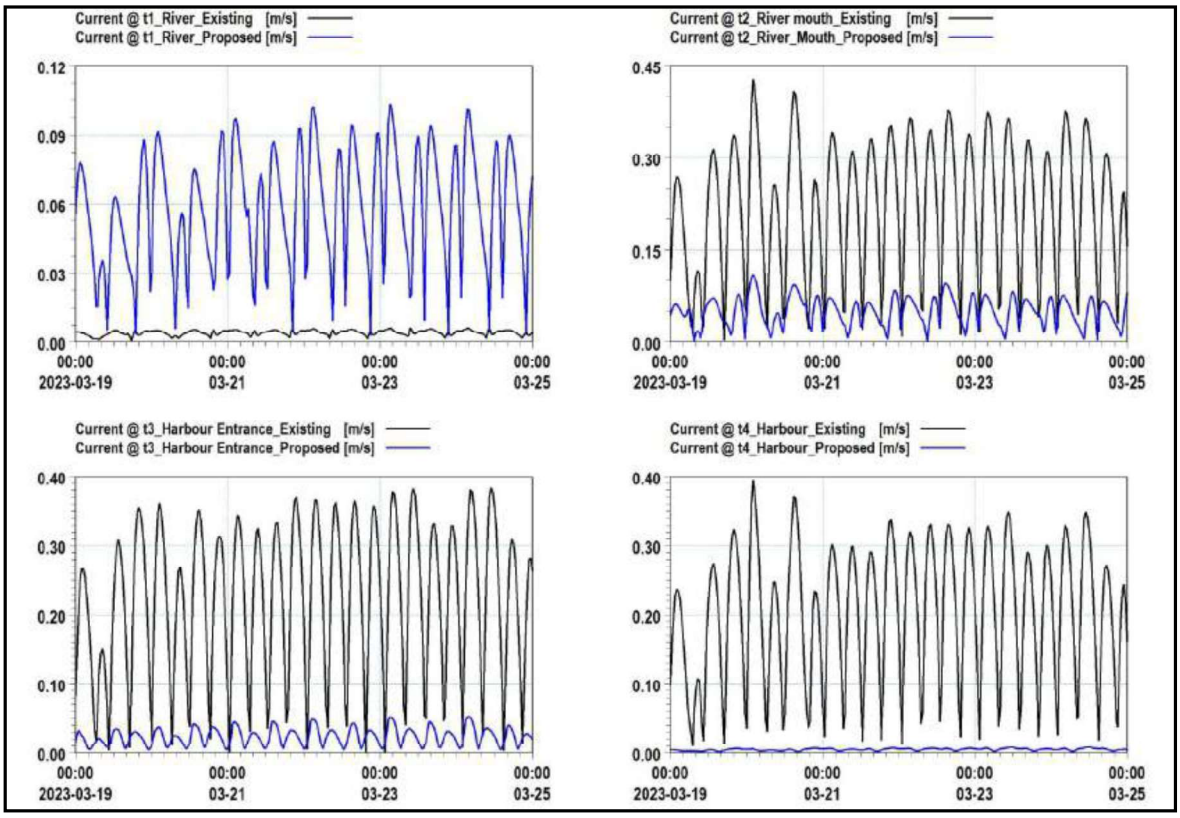


Figure 25: Currents at monitoring stations during Non-monsoon season
(Existing Vs Proposed condition)

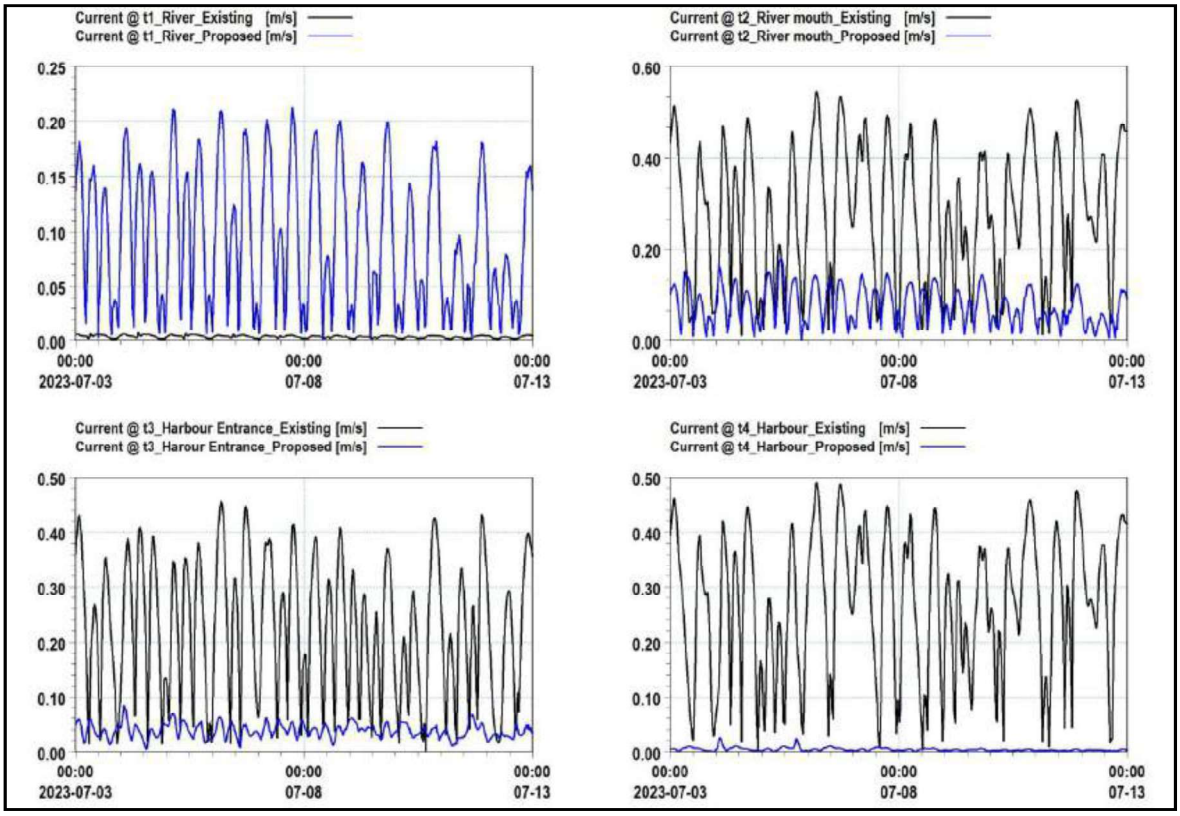


Figure 26: Currents at monitoring stations during Monsoon season
(Existing Vs Proposed condition)

6.6 Sedimentation Studies – Proposed condition- non-monsoon & monsoon seasons

The sedimentation studies were carried out for the proposed conditions for both non-monsoon and monsoon seasons by using MIKE 21 MT module over a period of one month. The sedimentation pattern during non-monsoon and monsoon seasons are shown in Fig. 27 and Fig. 28 respectively. During the monsoon season, there is slight increase in deposition (Fig. 28) at the river mouth and below the southern breakwater as compared to non-monsoon season. The annual sedimentation estimated in the Fishing Harbour is about 0.03m and at the North and South side of the proposed development annual sedimentation is estimated to be about 0.05m. The annual sedimentation estimated at the river mouth is about 0.045m for the proposed condition. The deposition of sediments near the north and south breakwater is majorly due to formation of circulation at these locations.

The sedimentation estimated is slightly higher in the river mouth region for the proposed condition as compared to the existing condition. The minor increase in sedimentation for the river mouth of proposed condition can be attributed to decrease in currents after establishing the proposed layout.

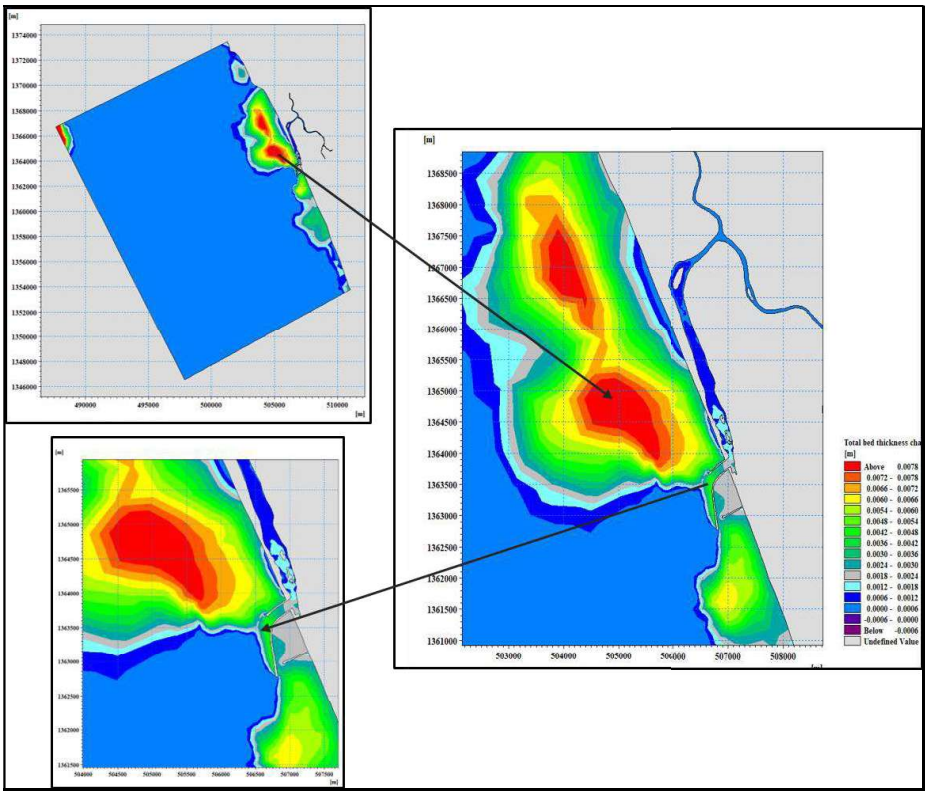


Figure 27: Sedimentation pattern during Non-monsoon season (Proposed)

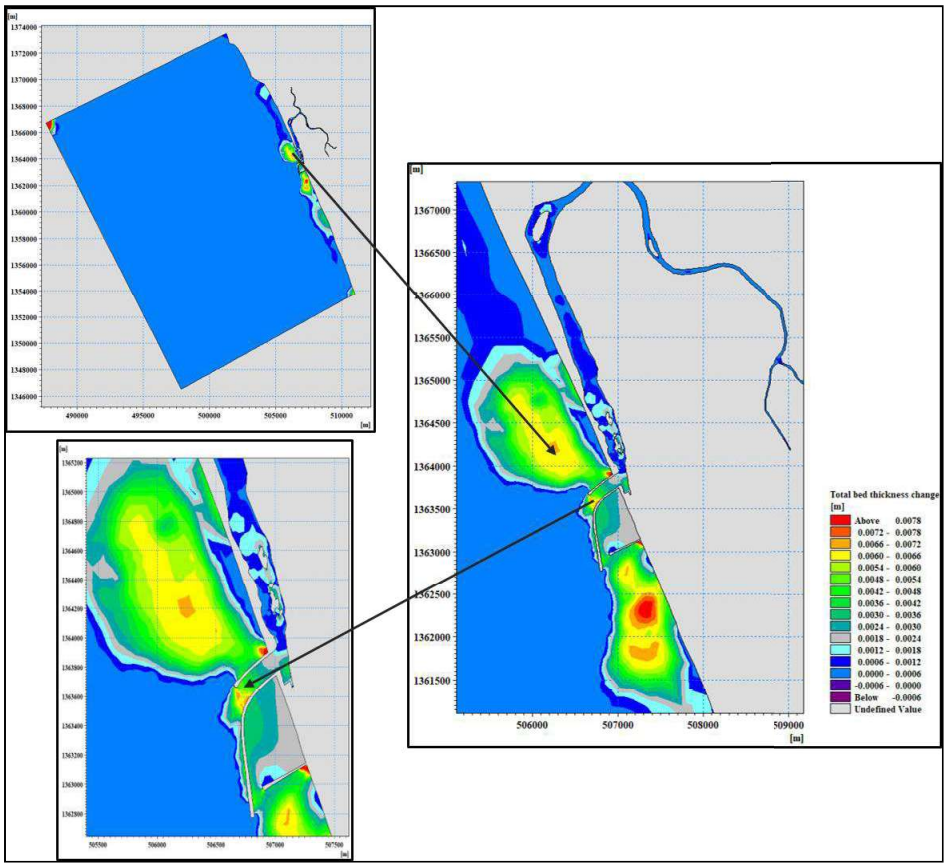


Figure 28: Sedimentation pattern during Monsoon season (Proposed)

6.7 Effect of Littoral Drift

Due to littoral drift, accretion and erosion are taking place on the north and south sides of the proposed development, respectively. The shoreline evolution after 10 years is predicted as accretion on the northern side extending up to 2500m along the shore and about 68m in cross-shore direction, and as erosion on the southern side extending up to 1500m along the shore and about 40m in cross-shore direction. It is observed that the shifting of the river mouth is about 200m towards the north over a year. If the shifting of the river mouth is pronounced after the proposed development of the river training works then a seawall of appropriate length may be provided to arrest the shifting of the river mouth. Similarly, if the erosion on the south side of the proposed fishing harbour is progressive after the development then a suitable shore protection measure in the form of a seawall or series of groynes may be provided.

7.0 CONCLUSIONS

The mathematical modelling studies for the proposed fishing harbour at Ajanur are undertaken. The simulations of hydrodynamics and sedimentation are performed for the existing conditions and for the proposed layout. Both non-monsoon and monsoon seasons are considered. The major conclusions of the study are given below:-

(i) In the existing condition, the hydrodynamic model results during non-monsoon season shows good calibration of the model with the field observed data.

(ii) The sedimentation studies for the existing condition shows some promising results of sedimentation pattern. Under the existing conditions, the estimated annual sedimentation i.e., depth of deposition is about 0.021m at the river mouth.

(iii) For the proposed development, due to dredging in the proposed area, modelling studies shows decrease in the currents in most of the area of study region (monitoring stations t2, t3 and t4) as compared to the existing condition.

(iv) The sedimentation pattern for the proposed condition shows sedimentation of the order of 0.045m per annum near the river mouth. Sedimentation is also noticed near the north and the south breakwaters (0.05 m in a year). In the fishing harbour area sedimentation of about 0.03 m in a year is estimated.

(v) If the erosion on the south side of the proposed fishing harbour is progressive after the development then a suitable shore protection measure in the form of a seawall or series of groynes may be provided.

(vi) If the shifting of the river mouth is pronounced after the proposed development of the river training works then a seawall of appropriate length may be provided to arrest the shifting of the river mouth.

(vii) The capital dredging in the fishing harbour area, in the river mouth and along the river is calculated to be about 1.1Mm^3. During the construction phase there are debris getting deposited in the dredged area. Therefore, this factor should also be considered for effective planning of construction. Also, maintenance dredging should be carried out near the river mouth and at the harbour entrance to maintain the desired depth for smooth movement of marine vessels.

(viii) The study suggest a proposed layout consisting of 1150m long north breakwater, 425m long south breakwater and 435m breakwater as a river training work near the mouth of Chittari river.

8.0 REFERENCES

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2. CWPRS Technical Report No.5436, “Wave propagation studies to determine wave climate for the development of fish landing facilities at Ajanur Dist. Kasargod, Kerala” (November 2016).
3. MIKE21- Flow Model FM, “User guide for Hydrodynamics module and Mud Transport Module”, Danish Hydraulic Institute (2014).

Annexure-I








Photographs at Ajanur Fishing Harbour

Environmental Impact Assessment Report

for

Proposed Construction of Ajanur Fishing Harbour

at

Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State

Fish Landing Capacity: 28,695 Tonnes Per Annum

[Schedule as per EIA Notification: Not applicable

Category: Standalone CRZ Clearance]

by

Harbour Engineering Department

Government of Kerala

Harbour Engineering Kasaragod Division,
Office of the Executive Engineer,
Clock Tower Junction, Near Railway Station, Kasaragod, Kerala – 671121

Prepared by

(Environmental Consultancy and Laboratory)
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NABET Certificate No.: NABET/EIA/24-27/RA 0378; valid till 18.10.2027

Document No: UTC/EIA/CRZ/00216/2024/01/02
EIA Execution Period: 12.07.2022 – 19.09.2025

Laboratory Used: Envirodesigns Eco Labs (NABL Certificate No: TC-7714, valid up to 18.10.2025)

Eco Tower, Janatha Jn., Palarivattom,
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Phone: + 91 9388609505

General Conditions as per EIA Notification: Not Applicable
Specific Conditions as per EIA Notification: Not Applicable
Period of Baseline Data Collection: 19.12.2022 – 14.03.2023

September 2025

Revision History						
S. No.	**Document Reference No.**	**Issue No.**	**Revision No.**	**Revision Date**	**Brief Description of the Revision**	**Reason for Revision/ Amendment**
1.	UTC/EIA/CRZ/00216/2024	01	00	29.11.2024	-	Draft
2.		01	01	26.08.2025	-	Internal Review
3.		01	02	19.09.2025	Revision in project cost	Review by Project Proponent

Disclaimer:

This Environmental Impact Assessment (EIA) report has been prepared with all reasonable skills, knowledge, care and diligence by NABET accredited EIA Consultant, ULTRA TECH, in accordance with the terms of the contract (Agreement No. 13/2022-23/EE/HED/KGD dated 12/07/2022) with Harbour Engineering Department, Government of Kerala, the project proponent, incorporating General Terms and Conditions of Contract and taking in to account of the resources devoted to it, for the submission to Kerala Coastal Zone Management Authority, for consideration for CRZ clearance. The report was discussed with project proponent, in detail before releasing.

This EIA report has been prepared using information received from project proponent, collecting primary data and compilation of secondary data from available resources. ULTRA TECH is not responsible for the origin and authenticity of the information provided by proponent. Neither this report nor any of its contents can be used for any purpose other than stated above, without the prior written consent from the project proponent.

Undertaking

(As per OM No. :- J.11013/41/2006/IA-II(I) Dated: 05-10-2011 by MoEF&CC, New Delhi, Govt. of India)

Date: 19.09.2025

I, Executive Engineer & Authorized Signatory of Harbour Engineering Division, Kasaragod do hereby confirm that, ULTRA TECH (NABET Accreditation no: NABET/EIA/24-27/RA 0378 valid till 18.10.2027) has prepared the EIA report for the 'Proposed Construction of Ajanur Fishing Harbour' at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State

I hereby undertake the ownership of the EIA report and confirm that I will be accountable for all the project related information mentioned in the report.

Executive Engineer & Authorized Signatory
Harbour Engineering Division, Kasaragod
Office of the Executive Engineer,
Clock Tower Junction, Near Railway Station,
Kasaragod, Kerala – 671121

Annexure VII as per scheme of accreditation by QCI-NABET

Part A: Declaration by ACO Experts Contributing to the EIA

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

EIA coordinator (EC):

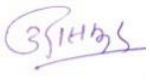
Name: Dr. Vikrant Kulkarni

Signature and Date: 

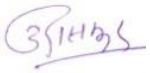
Period of involvement: July 2022 to September 2025

Contact information: vikrant@ultratech.in

Functional area experts:

S. No.	Functional areas	Name of the expert/s	Involvement (period and task)	Signature and date
1.	Air pollution monitoring, prevention and control (A)	Ms. Ananthitha A	***Involvement Period:*** Four Months ***Task:*** Air pollution monitoring, identification of impacts and mitigation measures, contribution to EIA documentation	
2.	Water pollution monitoring, prevention and control (WP)	Ms. Ananthitha A	***Involvement Period:*** Three Months ***Task:*** Water & waste water monitoring, water balance, identification of impacts and mitigation measures, contribution to EIA documentation	
3.	Solid and hazardous waste management (SHW)/ Solid waste management (SW)	Mr. Kailash Nath Sharma	***Involvement Period:*** One Month ***Task:*** Identification of hazardous and non-hazardous waste, contribution to EIA documentation	
4.	Socio- economics (SE)	Mr. Yogesh Raskar	***Involvement Period:*** Two Months	

S. No.	Functional areas	Name of the expert/s	Involvement (period and task)	Signature and date
			Task: Conducting baseline socio-economic surveys, conducting social need assessment, evaluation of socio-economic status, contribution to EIA documentation	
5.	Ecology & biodiversity (EB)	Dr. Vikrant Kulkarni	***Involvement Period:*** Two Months ***Task:*** Preparation of status report of rare, endangered and threatened species of flora & fauna, impact assessment, contribution to EIA documentation	
6.	Hydrology, ground water & water conservation (HG)	Mr. S. I. Tanweer	***Involvement Period:*** One Month ***Task:*** Analysis of surface hydrological data, contribution to EIA documentation	
7.	Geology (GEO)	Not involved[#]	-	-
8.	Soil conservation (SC)	Ms. Padmini Shinde-Barde	***Involvement Period:*** Three Months ***Task:*** Sampling, analysis and characterization of soil, assessment of impacts, remediation for soil pollution, contribution to EIA documentation	
9.	Meteorology, air quality modelling & prediction (AQ)	Not involved[#]	-	-
10.	Noise & vibration (NV)	Mr. Arun Kumar	***Involvement Period:*** Three Months ***Task:*** Monitoring of noise/vibration, identification of impacts and mitigation measures,	

S. No.	Functional areas	Name of the expert/s	Involvement (period and task)	Signature and date
			contribution to EIA documentation	
11.	Land Use (LU)	Mr. Yogesh Raskar	***Involvement Period:*** One Month ***Task:*** Generation of data for land use pattern, developing land use map, integration of land use data and impact assessment, contribution to EIA documentation	
12.	Risk assessment & hazards management (RH)	Mr. Kailash Nath Sharma	***Involvement Period:*** One Month ***Task:*** Identification of hazard and hazardous substances, preparation of on-site Emergency Preparedness Plan, preparation of impact diagrams, contribution to EIA documentation	

#as per the rationalization of the scheme of accreditation of NABET

Part B: Declaration by Head of the ACO / authorized person

I, Niranjan Shekhar Tamhane, hereby, confirm that the above-mentioned experts prepared the EIA report for the project 'Proposed Construction of Ajanur Fishing Harbour' at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State and EIA Coordinator (EC) is fully aware of the content. The consultant organization shall be fully accountable for any mis-leading information. It is also certified that EIA Report has been analysed by the system for plagiarism check using Plagiarism Checker X software in accordance with good scientific practice. No unethical practices have been carried out and external data / text has not been used without proper acknowledgement, while preparing this EIA report.

Certificate of Plagiarism check	
Title of EIA Report:	Environmental Impact Assessment Report for Proposed Construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State
Name of Accredited Organisation:	ULTRA TECH
Unique Identification Number:	UTC/EIA/CRZ/00216/2024
Name of EIA Co-ordinator:	Dr. Vikrant Kulkarni
Name of the Software:	Plagiarism Checker X
Date of Check:	19.09.2025
Time of Check:	09.25 AM

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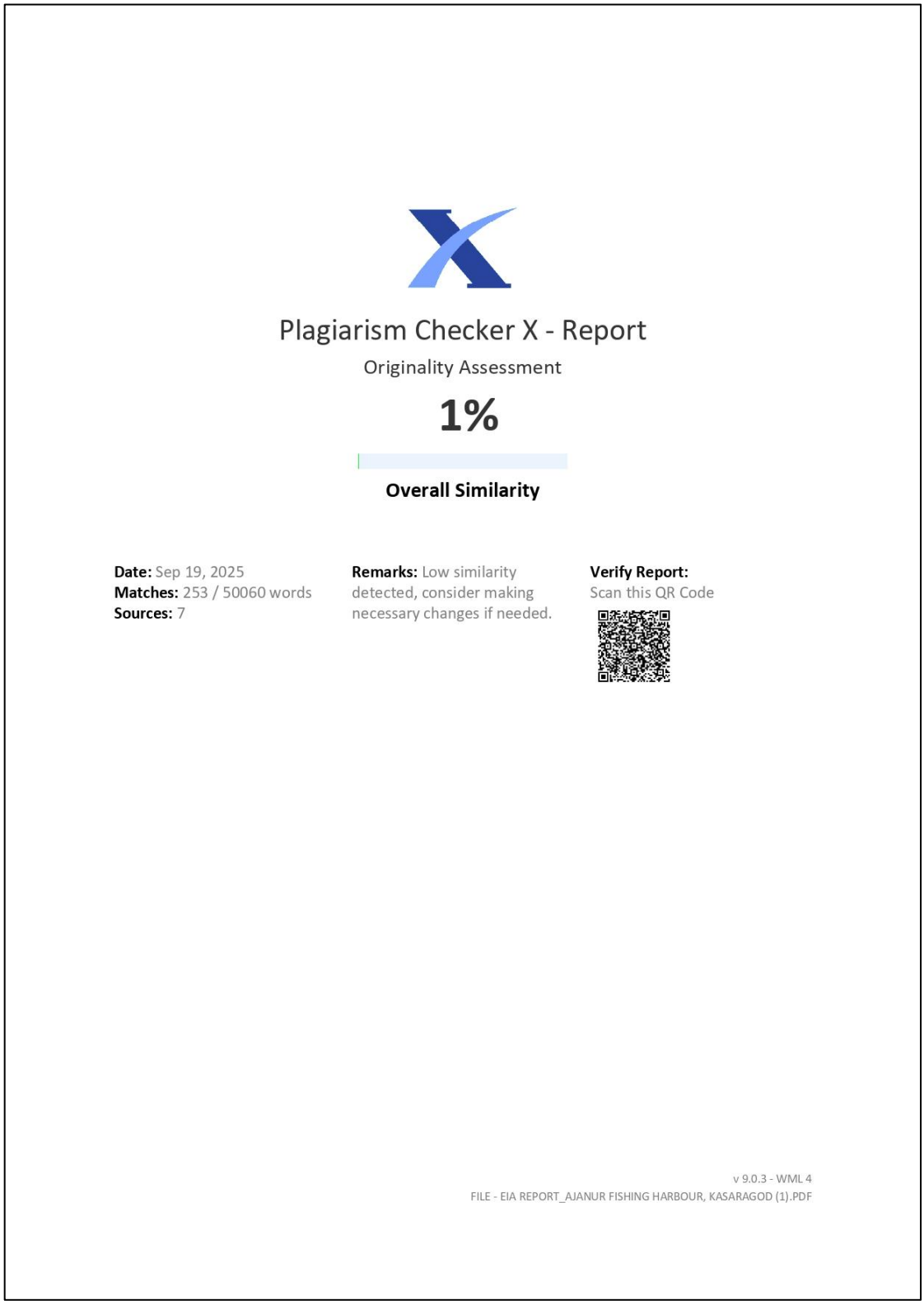
Name: Dr. Vikrant Kulkarni
Designation: EIA Co-ordinator Signature

Date and Sign of Head of ACO / authorised person:



Name: Niranjan Shekhar Tamhane
Designation: Proprietor & Managing Director
Name of the EIA consultant organization: ULTRA TECH
NABET Certificate No. & Issue Date: NABET/EIA/24-27/RA 0378; valid till 18.10.2027

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List of Annexures

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Annexure - 2	NABET Accreditation Certificate of EIA Consultant
Annexure - 3	NABL Certificate of the Laboratory

List of Abbreviations

Abbreviations		Description
ACO	:	Accredited Consultant Organization
AEE	:	Assistant Executive Engineer
AMSL	:	Above Mean Sea Level
AQI	:	Air Quality Index
BDL	:	Below Detection Limit
BMTPC	:	Building Materials and Technology Promotion Council
BOD	:	Biochemical Oxygen Demand
CER	:	Corporate Environmental Responsibility
CGWA	:	Central Groundwater Authority
COD	:	Chemical Oxidation Demand
CPCB	:	Central Pollution Control Board
CRZ	:	Coastal Regulation Zone
CTE	:	Consent to Establish
CTO	:	Consent to Operate
CWPRS	:	Central Water & Power Research Station
CZMP	:	Coastal Zone Management Plan
DDMA	:	District Disaster Management Authority
DDMP	:	District Disaster Management Plan
DEM	:	Digital Elevation Model
DG	:	Diesel Generator
DMP	:	Disaster Management Plan
DPR	:	Detailed Project Report
DO	:	Dissolved Oxygen
EIA	:	Environmental Impact Assessment
EMC	:	Environment Management Cell
EMP	:	Environment Management Plan
ERDMP	:	Emergency Response and Disaster Management Plan
ETP	:	Effluent Treatment Plant
FCC	:	False Colour Composite
FLC	:	Fish landing Centre
GHG	:	Greenhouse Gases
GIS	:	Geographic Information System
HED	:	Harbour Engineering Department
HSE	:	Health Safety and Environment
HTL	:	High Tide Line
INR	:	Indian Rupee
IS	:	Indian Standard
IUCN	:	International Union for Conservation of Nature
KCZMA	:	Kerala Coastal Zone Management Authority

Abbreviations		Description
KCZMP	:	Kerala Coastal Zone Management Plan
KSDMA	:	Kerala State Disaster Management Authority
KSDMP	:	Kerala State Disaster Management Plan
KSEB	:	Kerala State Electricity Board
KSPCB	:	Kerala State Pollution Control Board
KWA	:	Kerala Water Authority
LTL	:	Low Tide Line
LULC	:	Land Use – Land Cover
MBBR	:	Moving Bed Biofilm Reactor
MDL	:	Minimum Detection Limit
MoEF&CC	:	Ministry of Environment Forest and Climate Change
MPN	:	Most Probable Number
NAAQS	:	National Ambient Air Quality Standards
NABET	:	National Accreditation Board for Education and Training
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NASA POWER	:	National Aeronautics and Space Administration – Prediction of Worldwide Energy Resources
NCESS	:	National Centre for Earth Science Studies
NH	:	National Highway
NOC	:	No-Objection Certificate
NTU	:	Nephelometric Turbidity Unit
PCC	:	Plain Cement Concrete
PMMSY	:	Pradhan Mantri Matsya Sampada Yojana
PPE	:	Personal Protective Equipment
PUC	:	Pollution Under Control
RCC	:	Reinforced Cement Concrete
RWH	:	Rain Water Harvesting
SC	:	Scheduled Caste
SDMP	:	State Disaster Management Plan
SEIAA	:	State Environmental Impact Assessment Authority
SH	:	State Highway
SOP	:	Standard Operating Procedures
ST	:	Scheduled Tribe
STP	:	Sewage Treatment plants
ToR	:	Terms of Reference
WPA	:	Wildlife Protection Act

Executive Summary

1. Project Name and Location

The proposed project is the construction of a fishing harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State, next to the mouth of Chithari River, with a fish landing capacity of 28,695 Tonnes Per Annum (TPA). Presently, there is a fish landing centre at the proposed project site which has a dilapidated auction hall, net mending shed and a toilet block. Apart from this, the mouth of the river is migratory in nature, and its shifts are so drastic that it even damaged the existing fish landing centre facilities. Low discharge in the river during the summer season causes sand bar formation and closure at the mouth which leads to flash floods at the densely populated upstream coastal area during the onset of monsoon.

Inadequate facilities at the fish landing centre, migratory nature of the river mouth and sand bar formations poses life threatening risks to the fishers navigating the mouth to earn their daily income for the fishers and limits utilising the Ajanur coast to its full potential. Over 500 fishing vessels experience significant challenges in navigating the area. As a permanent solution to these pestering issues, Harbour Engineering Department (HED) proposed to construct an open sea fishing harbour at Ajanur along with river training structures to stabilise the river mouth.

Ajanur Fishing Harbour will consist of a northern and southern breakwater, south of the river mouth and adequate landside facilities such as wharf, auction hall, berthing wharf, etc. to aid fish landing and handling, along with necessary facilities for the fishers such as rest shed, canteen, gear shed, toilet block, etc. To ensure security at the harbour, locker room, office room cum harbour surveillance camera room, gate and gate house, etc. will be provided. The landside facilities will also be provided with Effluent Treatment Plant (ETP), Rain Water Harvesting (RWH) tanks and solar panels as power source for the entire harbour facilities for the efficient environmentally friendly management of the harbour.

On the north of the river mouth, a river training breakwater is proposed. The northern breakwater of the harbour will act as the southern river training breakwater. The proposed project will increase number of fishing days to more than 300 days and attracting more fishing vessels into the harbour. The project is in accordance with the directions of Ministry of Fisheries, Animal Husbandry and Dairying, as per the guidelines of Pradhan Mantri Matsya Sampada Yojana (PMMSY).

The basic details of the project and the project proponent are given in Table 1.

Table 1: Basic details of Project & Proponent

Particulars	Descriptions
Name of Project	Proposed Construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State
Project location	Northern breakwater: 12°20'11.66"N, 75° 3'53.04"E Southern breakwater: 12°19'55.64"N, 75° 3'58.95"E River training works: 12°20'17.39"N, 75° 3'51.34"E Fishing Harbor facilities: 12°20'10.18"N, 75° 3'54.87"E
Project Proponent	Harbour Engineering Department, Government of Kerala

Particulars	Descriptions
Authorized signatory of the Project Proponent	Executive Engineer Harbour Engineering Division, Kasaragod

The project site falls under Coastal Regulation Zone (CRZ) IA, CRZ IB, CRZ II, CRZ IVA and CRZ IVB, based on CRZ map prepared by National Centre for Earth Science Studies (NCESS), Thiruvananthapuram in May 2025 and therefore requires CRZ clearance from Kerala Coastal Zone Management Authority (KCZMA) in accordance with CRZ Notification 2019. ULTRA TECH has carried out the Environmental Impact Assessment (EIA) studies and preparation of Environmental Management Plan (EMP) for obtaining CRZ clearance.

2. Product and Capacity

The salient features of the project are given in Table 2.

Table 2: Salient Feature of the Project

<table>
<tr><th>Particulars</th><th>Description</th></tr>
<tr><td>Total fish landing capacity</td><td>28,695 TPA</td></tr>
<tr><td>Details of fishing vessels</td><td>
<table>
<tr><th>Overall Vessel Length (m)</th><th>No. of Vessels</th><th>Fishing Trip (Days)</th><th>Fishing Trips per Year</th><th>Average Daily Landing (kg)</th><th>Fish Landing Capacity/Year (kg)</th></tr>
<tr><td>8</td><td>30</td><td>1</td><td>220</td><td>50</td><td>3,30,000</td></tr>
<tr><td>10</td><td>50</td><td>1</td><td>150</td><td>700</td><td>52,50,000</td></tr>
<tr><td>15</td><td>553</td><td>1</td><td>44</td><td>950</td><td>2,31,15,400</td></tr>
<tr><td colspan="5">Total</td><td>2,86,95,400</td></tr>
</table>
</td></tr>
<tr><td>Proposed activities</td><td>

Construction of harbour basin with two breakwaters, north breakwater of 1,150 m length and south breakwater of 425 m length.
River training structure in the form of a breakwater of length 435 m on the north of the mouth of Chithari River
Landside facilities for the harbour which includes wharf of dimension 120 m × 6.6 m and auction hall of dimension 60 m × 15 m, berthing wharf, canteen, rest shed, locker room, gear shed, toilet block, workshop building, office room cum harbour surveillance camera room, gate and gate house with ATM and toll booth, ETP, RWH, development of green area, approach road, internal road, parking area, drainage facility, compound wall and side protection work, etc.
Dredging proposed in between the north breakwater and river training work at the mouth of river Chithari
Dredging and construction of reclamation bund

</td></tr>
</table>

Particulars	Description
	• The harbour will be developed with smart infrastructures like digital platforms for information dissemination, electronic auctions for broader market access, automated systems for sorting, grading, and cataloguing catches, Hazard Analysis Critical Control Points (HACCP) integration, and surveillance systems.
Period of construction	46 Months
Beneficiary population	• Local population in 3 fishing villages; Hosdurg, Ajanur and Pallikkara. • Beneficial for 7,094 people with 2,138 registered fishermen

3. Resource Requirement

The resource requirement of the project is depicted in Table 3.

Table 3: Resource Requirement for the Project

<table>
<tr><th>S. No.</th><th>Particulars</th><th>Construction Phase</th><th>Operation Phase</th></tr>
<tr><td>1.</td><td>Water requirement</td><td>
<table>
<tr><th><u>Details</u></th><th><u>:</u></th><th><u>Quantity</u></th></tr>
<tr><td>Construction Activities</td><td>:</td><td>2 kLD</td></tr>
<tr><td colspan="3">Construction Workers</td></tr>
<tr><td>Domestic Purposes</td><td>:</td><td>2.5 kLD</td></tr>
<tr><td>Flushing</td><td>:</td><td>2 kLD</td></tr>
<tr><td>Total</td><td></td><td>6.5 kLD</td></tr>
</table>
Source: Purchase in tankers</td><td>
<table>
<tr><th><u>Details</u></th><th><u>:</u></th><th><u>Quantity</u></th></tr>
<tr><td>Domestic Purposes</td><td>:</td><td>4 kLD</td></tr>
<tr><td>Flushing</td><td>:</td><td>6 kLD</td></tr>
<tr><td>Fish handling area washing</td><td>:</td><td>6 kLD</td></tr>
<tr><td>Total</td><td></td><td>16 kLD</td></tr>
</table>
Source: Kerala Water Authority (KWA)</td></tr>
<tr><td>2.</td><td>Power requirement</td><td>Temporary connection from Kerala State Electricity Board Limited (KSEB) will be used.</td><td>Harbour will be fully solar powered using solar panels of total capacity of 30 kW.</td></tr>
<tr><td>3.</td><td>Workforce requirement</td><td>Direct employment for about 100 workers/ day</td><td>15 operational staff for the landside facilities</td></tr>
<tr><td>4.</td><td>Transport Infrastructure</td><td>The access to the site is from a public road having about 5 m width. Crescent Road and Palayi - Kanhangad Road links the access road with SH 57.</td><td>• 2-way 2 lane internal road of 4 m width will be developed
• Parking area of 4,320 m^2</td></tr>
</table>

4. Brief Description of Process

The final layout of the fishing harbour and river training walls were decided based on the Modelling study by Central Water & Power Research Station (CWPRS), Pune. Breakwaters of the harbour and for river training works will be constructed with blasted rock from approved quarry varying from sizes 5 kg to 3T and tetrapod of 2T, 6T and 8T.

Reinforced Cement Concrete (RCC) structures with strong foundation and other building components such as concrete beams, slabs, columns, etc, will be made with optimized design considering environmental conditions at the project area.

5. Project Cost and Schedule

Estimated capital cost of the proposed constructions is INR 20,000 Lakhs. It will be funded under Pradhan Mantri Matsya Sampada Yojana (PMMSY) scheme by the Central Government and State Government in the ratio 60:40. The project will commence after receiving CRZ clearance from KCZMA, Kerala.

6. Selection of Project Site

The final location and layout for the fishing harbour was decided after considering various location and alignment options and conducting mathematical modelling studies on tidal currents, wave tranquillity study, sedimentation pattern, littoral drift, and shoreline evolution by CWPRS.

7. Details of Environmental Baseline

- The study area for conducting EIA studies includes a 10.0 km area around the project site. The core zone includes the project site and a radius of 2.0 km from the project site. The buffer zone includes the area outside the core zone and extends up to 10.0 km radius from the project site.
- Baseline monitoring was done for environment and social parameters during the study period from 19.12.2022 to 14.03.2023 through reconnaissance survey followed by field visits, collection of samples, stakeholder consultations & door-to-door household surveys.
- Lakshadweep sea and Chithari River are part of the project site.
- No reservoirs/dams, tiger reserve, elephant reserve, biospheres, national parks, wildlife sanctuaries, community reserves, conservation reserves, reserve/protected forest, unique or threatened ecosystem, critically polluted environmental area, coastal areas rich in corals, mangroves, breeding grounds of specific species and estuaries rich in mangroves, breeding ground of specific species within 10 km study area.
- As per the notified groundwater zone by Central Ground Water Authority (CO), Assessment Unti - Kanhangad, where the project site is located, falls under safe area.
- New Life Maternity Hospital, Athinhal is located 1.39 km, NE from Northern Breakwater. Crescent School, New Building, Kothikkal, and G.F.U.P.S Ajanur Kadappuram School are the nearest educational institutions. Muhiyudheen Juma Masjid Kothikkal, Muttumthala Juma Masjid, Muttumthala and Sidiqual Bilal Masjid, Ettammal are the nearest religious structures located within 2 km of the project site.
- The results of environmental baseline monitoring of ambient air, noise level, surface water, soil, marine water and marine sediment are given in Table 4.

Table 4: Summary of Environmental Baseline Monitoring

S. No.	Parameter	No. of Locations	Inference
1.	Ambient Air Quality	3	All tested parameters, PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO are found within prescribed limits of National Ambient Air Quality Standards (NAAQS) - 2009
2.	Ambient Noise level	3	Noise Levels are within the permissible limits as per Noise Pollution (Regulation & Control) Rules, 2000
3.	Surface water	1	The water exhibits low color intensity, agreeable odor, and turbidity indicating minimal organic pollution. However, its high hardness, chlorides, dissolved solid, and sulphates render it salty and unsuitable for drinking. The presence of phytoplankton and zooplankton indicates a healthy aquatic ecosystem.
4.	Soil	1	The soil sample was sparsely acidic with low organic content and high electrical conductivity indicates a high level of salinity. It was observed that fertility of soil sample is poor in terms of organic matter.
5.	Marine Water	2	Marine water samples collected demonstrated good quality typical for marine sea water, featuring optimal pH, low coliform bacteria, and adequate dissolved oxygen for marine life. Minimal organic pollution, low nutrient levels, and negligible industrial contaminants indicate a healthy marine environment with no significant eutrophication or pollution concerns.
6.	Marine Sediment	2	Sediment sample quality is generally good at sampling locations. Presence of benthic organisms indicating overall health of the marine ecosystem.

- Through satellite image analysis for land use land cover study using Q-GIS software for 2 km and 10 km study area, it was observed that the area is dominated by water bodies.
- The project site falls in Zone III (moderate seismic intensity) as per Seismic Map of India (IS: 1893, Part I, 2002).
- Study area experiences a tropical and unique climate with an oppressive summer and plentiful seasonal rainfall. As per the Agro-climatological data for the year 2022 collected from NASA POWER for the project location. Maximum temperature experienced was during March (35.1°C) and minimum during the month of January (21.14°C). Maximum precipitation is experienced in the month of July, whereas the study area received negligible rainfall during the month of November. Relative humidity is generally high ranging between 66.75% and 90.94%. The highest wind speed was found to occur during the months of July.
- Wind zone is Moderate Damage Risk Zone – B (Vb = 39 m/s) as per the Wind & Cyclone Hazard Map published by the Building Material & Technology Promotion Council (BMPTC), Ministry of Housing & Urban Affairs (MoH), Government of India (GoI). The predominant wind direct is from west to east direction.

- No threatened, endangered & endemic species and migratory fauna were observed in the study area as per International Union for Conservation of Nature (IUCN) Red List of Threatened Species. *Ptyas mucosa* (Rat Snake), *Haliastur indus* (Brahminy Kite), Schedule I species as per Wildlife (Protection) Amendment Act, 2022 were found in the study area.
- Socio-economic survey for the project was carried out through stakeholder consultation and door-to-door surveys with structured questionnaires. Survey revealed the following;
  - The fishers find it extremely difficult to navigate the mouth due to its migratory nature and closure of mouth. The sandbar formations at the mouth demands manual dredging and opening of the mouth to re-facilitate movement of vessels.
  - The region faces recurring threats of flooding and sea encroachment.
  - Saltwater intrusion is an issue and therefore the coastal residents depend exclusively on pipeline water to meet their daily water requirement.
  - Local elected representatives suggest constructing sea walls to address coastal erosion.

8. Identification of Hazardous Material

No hazardous material is being handled or envisaged to be handled at the fishing harbour. Fuel used for machineries and waste oil shall be securely stored in designated locations and shall be timely handed over to the authorized dealers.

9. Anticipated Impacts and Mitigation Measures

During construction phase, activities such as transportation and handling of materials, increased vehicular movement, operation of construction equipment, work in the water body etc. may disrupt and cause discomfort to fishermen, current fish landing centre users and the local community if adequate mitigation measures are not adopted. The major impacts during the operation phase are anticipated to arise from increased vessel activity and expanded fish landing attracting influx of people and thereby increasing stress on the available natural resources like fresh water.

Several project features mitigate the environmental impacts including:

- CWPRS has designed the breakwaters for the harbour and for river training works in accordance with modelling studies using the site-specific data and optimising the design as per the suggestions of Harbour Engineering Department (HED) after conducting necessary desk studies, for maximum efficient control over river mouth migration and for providing tranquil conditions in the harbour basin.
- The landside facilities are proposed in government owned land and therefore there is no need for land acquisition.
- The project includes comprehensive environmental management measures such as wastewater treatment, improved stormwater drainage, rainwater harvesting, upgraded internal roads and expanded parking facilities.
- No tree cutting is proposed for the project. To improve the ecosystem, the project includes green area development and landscaping.

The anticipated environmental impacts and the corresponding mitigation measures which shall be adopted for construction phase is given in Table 5.

Table 5: Anticipated Impacts and Mitigation Measures for Construction Phase

Anticipated Environmental Impacts	Mitigation Measures Proposed
Excavation, reclamation and construction activities and waste disposal can impact land stability and soil quality	• Reclamation shall be carried out only in the earmarked areas, using the dredged material from maintenance dredging of the river mouth and harbour basin, to the maximum extent. • Construction in and near the water bodies shall be done as per the SOPs prepared • Implement proper waste management practices & restore the site to its original state after construction.
Construction activities may cause pollution, sedimentation and changes in water flow, which negatively impacting surface water, groundwater and marine water quality.	• Groundwater withdrawal shall not be done from CRZ areas. • Turbidity caused during dredging shall be limited by periodically suspending dredging activities when the turbidity spreads beyond the area earmarked for dredging • Drains shall be constructed in initial stages of the construction of the landside facilities for the efficient management of storm water runoff from the site. • Proper storage of oil and fuel at designated locations. • Use portable Sewage Treatment plants (STPs) for treating wastewater generated by the construction workers.
Construction activities and vehicle traffic can generate noise and dust emission, which leading to air and noise pollution and causing inconvenience to the public.	• Regular maintenance of machineries and vehicles and use vehicles with valid PUC. • Use low-emission equipment and maintain the machineries regularly. • Transporting construction materials in covered vehicles • Profile sheet barricades shall be provided around the proposed harbour facilities • Prohibit unnecessary idling of construction vehicle.
Construction activities, oil spills and plastic waste can harm the habitats of terrestrial and marine flora and fauna.	• Training and awareness for the construction workers. • Prompt removal construction debris. • Minimize land and vegetation use outside construction area. • Proper solid waste management. • Safe disposal of oil and other residues.
Health and life risk to workers due to lack of access to potable water, unsanitary conditions and accidents during construction activities.	• Provision for potable water facilities. • Implementation of proper sanitation and waste management system for liquid and solid waste. • Provide training on Health Safety and Environment (HSE) policies, SOPs etc. • Ensure proper use of PPE, enforce safety rules, provide adequate lighting, warning signs, suspend work during heavy

Anticipated Environmental Impacts	Mitigation Measures Proposed
	rains, establish early warning systems, first aid facilities, medical check-up and availability of trained staff for first aid.

The anticipated environmental impacts and corresponding mitigation measures which shall be adopted for operation phase is given in Table 6.

Table 6: Anticipated Impacts and Mitigation Measures for Operation Phase

Anticipated Environmental Impacts	Mitigation Measures proposed
Erosion on southern shoreline, continued migratory nature of the river mouth, disposal of solid and liquid waste, leakage of hazardous waste can impact the land environment	• Well-designed river training works to prevent sedimentation and sand bar formation in the river mouth. However, CWPRS has recommended that if the mouth remain unstable, then then seawall of appropriate length may be provided to arrest the shifting of the river mouth. • CWPRS has also recommended that if erosion progresses on the south coast of the harbour, then suitable shore protection such as seawall or series of groynes may be provided. • Proper liquid and solid waste management measures such as ETP of capacity 15 kLD and source segregation and handing over of solid waste. • Proper storage and handling of hazardous substances.
Increased water requirement, overexploitation of freshwater resources, contamination of waterbody and inadequate stormwater management can impact the water quality.	• Groundwater withdrawal shall be prohibited in CRZ areas. • RWH tanks of capacity 50 kL will be installed. • Reuse of treated water for watering of landscaping area. • Storm water drains with detention tanks shall be provided and it shall be desilted regularly.
Emissions from vessels, vehicles and working machinery can impact air environment and noise environment	• Proper fishing vessel management plan. • Implementation of proper traffic management plan with traffic circulation paths and parking areas within the site.
Increased movement of fishing vessels, over exploitation of marine resources and unsuitable afforestation practices may impact ecology and biodiversity	• Restriction of vessel anchoring and movement in sensitive areas. • Designation of vessel routes and speed restrictions. • Creation of protected areas for critical habitats. • Awareness training for fishers to avoid trapping of species that need environmental protection and against overfishing. • Species and location for green area development shall be selected in consultation with locals.

Anticipated Environmental Impacts	Mitigation Measures proposed
Inadequate sanitation and wastewater management, improper solid waste disposal, accidents and injuries among fishing can impact occupational health and safety.	• Adequate sanitation facilities for workers with adequate water supply with resting rooms facilities • Proper waste management measures for handling solid and liquid wastes • Pest control measures shall be adopted in the harbour premises • Enough staff trained in first aid measures and an ambulance with all necessary facilities shall always be deployed at the harbour.

The Environmental Management Plan (EMP) shall be scrupulously implemented to control the anticipated impacts. The implementation of EMP for the construction phase shall be under the scope of the construction contractor and the implementation of EMP during the operation phase shall be under the scope of HED. The budgetary allocation for EMP is given in Table 7.

Table 7: Budgetary Allocation for EMP

S. No	Environmental Management Measure	Capital Cost (In INR)	Recurring Cost/ year (In INR)
Construction Phase			
1.	Barricades of height 3.0 m around the construction areas	5,25,000	55,000
2.	Vehicle and equipment inspection camp	-	1,00,000
3.	Storm water management by a detention tank and seasonal desilting	55,000	30,000
4.	Wastewater management of 100 workers by providing temporary toilets connected to portable STP	3,75,000	1,05,000
5.	Oil Spill containment kits (Including Absorbent Pads, Absorbent Socks, Disposable Bags, Safety Goggle etc.)	10,000	5,000
6.	Solid waste management by 2 aerobic composting bins for biodegradable wastes and 2 bins for segregation and collection of plastics, paper, cans & others	1,00,000	40,000
7.	Ecological training for the workers on conservation and protection of the environment.	60,000	30,000
8.	Salary of HSE engineer for ensuring EMP is followed	-	3,00,000
9.	Erection of warning sign boards at both the sides	50,000	10,000
10.	HSE training for workers: 2-day induction training before start of construction and refresher training after 6 months	30,000	15,000
11.	PPE (helmet, jacket, shoes, life jacket, harness, googles, life jacket, etc) for 100 workers (working on land and in the sea) along with first aid facilities and water ambulance for workers	5,15,000	80,000
12.	Medical check-up camps for 100 workers, once in 6 months	-	1,00,000
13.	Grievance redressal system for workers	-	40,000

S. No	Environmental Management Measure	Capital Cost (In INR)	Recurring Cost/ year (In INR)
14.	Grievance redressal system for local population	-	40,000
15.	Informing people about construction & restriction on beach	15,000	-
16.	Erecting boards for traffic management within the harbour	35,000	-
17.	Site cleaning and restoration works	30,000	-
18.	EMC meetings, record keeping & site inspections	-	35,000
19.	Environmental Monitoring	-	2,46,000
	Total EMP Cost for Construction Phase	***18,00,000***	***12,31,000***
	Operation Phase		
1.	Maintenance of internal road and parking area	-	2,75,000
2.	Vehicle and equipment inspection camp	-	50,000
3.	Maintenance of RWH tanks of capacity 50 kL	-	50,000
4.	Maintenance and seasonal desilting of the storm water drains and detention tank	-	25,000
5.	Operational cost for proposed ETP of 15 kLD	-	2,10,000
6.	Solid waste management of the harbour by using 2 units of segregation and collection bins (for biodegradables, plastics, paper, cans & others) and handing over of the waste to authorised handlers	-	60,000
7.	Awareness training for fishers on safety, environmental responsibilities, latest eco-friendly & most modern fishing measurers, etc.	-	45,000
8.	Maintenance of landscapes and green belt developed	-	1,10,000
9.	Pest control at the harbour premises, quarterly	-	45,000
10.	Medical check-up for the fishers and workers at the harbour	-	2,00,000
11.	Grievance redressal system for harbour workers & fishers	-	50,000
12.	Maintenance of traffic management boards in the harbour and appointing a traffic warden for regulating traffic	-	10,000
13.	Grievance redressal system for locals	-	50,000
14.	EMC meetings, record keeping and site inspections	-	35,000
15.	Environmental Monitoring	-	2,85,000
16.	Shoreline mapping	-	1,00,000
	Total EMP Cost for Operation Phase	-	***16,00,000***

The total budget allocated for EMP during construction phase is INR 18.00 lakhs as capital cost and INR 12.31 lakhs/year as recurring cost. During operation phase the budget of EMP is INR 16.00 lakhs/year as recurring cost.

10. Emergency Preparedness

The possible naturals hazards in addition to anthropogenic hazards identified for the project include cyclone, lightning, earthquake, drought, flood and costal hazards. The risk to the project due to these

hazards and their consequences were analysed and the mitigation measures were proposed to reduce risks from these hazards. To ensure a seamless transition from normal condition to emergency operations in a systematic manner during the emergency, an Emergency Response Team with appropriate lines of authority with succession planning and actuating the response management at site has been identified. Contact numbers of concerned authorities and nearby emergency facilities are identified and shall be displayed in the site.

11. Public Hearing

This project does not require public hearing as it is a standalone CRZ project

12. Corporate Environmental Responsibility (CER)

CER is not applicable for the project as the project does not attract EIA Notification 2006.

13. Occupational Health Measures

Occupational health impacts occur due to inadequate sanitation, lack of solid waste and wastewater management system, contamination of drinking water sources and spread of waterborne communicable diseases. Lack of adequate safety measures/ training/ PPEs and accidents are also an issue.

To ensure a safe and sustainable construction process, proper waste management practices must be implemented, including portable STP and source segregation of solid waste & onsite composting of food waste. Construction workers should be provided with appropriate number of PPEs and trained on its proper use. First aid kits and a water ambulance shall always be readily available at the construction site. Medical camps for workers shall be arranged once in six months. The construction workers shall be given adequate training on HSE policy, Emergency Response and Disaster Management Plan (ERDMP), SOP for construction, etc.

To ensure proper waste management during operation phase, solid waste segregation at the source and handed over to authorised recyclers or handlers. Fishers must be trained on the importance of wearing appropriate PPE. Regular medical check-ups for fishers and harbour workers are essential for monitoring their health and well-being

14. Post Project Monitoring Plan

Environmental Monitoring Programme (EMoP) has been prepared to monitor the environmental quality during operation phase and shall be carried out through a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory. The parameters to be monitored are ambient air, noise level, soil, surface water, marine water, marine sediment, inlet and outlet water from Effluent Treatment Plant (ETP) and stack emissions from DG. The budget for EMoP during construction phase is estimated as INR 2.46 Lakhs/year and for the operation phase is estimated to be INR 2.85 Lakhs/year.

Half yearly compliance reports shall be prepared & submitted to KCZMA/MoEF&CC to ensure transparency and accountability of environmental performance.

Based on the EIA studies and other surveys conducted for the project can be concluded that the potential adverse environmental impacts can be mitigated to an acceptable level by adequate implementation of

the environment management measures. The stipulations in all the statutory compliances such as the CRZ Clearance shall be scrupulously followed and its compliance monitored and reported by the EMC.

Compliance to Standard Terms of References

S. No	Standard ToR	Compliance	Citation
1.	Reasons for selecting the site with details of alternate sites examined/ rejected/ selected on merit with comparative statement and reason/ basis for selection. The examination should justify site suitability in terms of environmental angle, resources sustainability associated with selected site as compared to rejected sites. The analysis should include parameters considered along with weightage criteria for short-listing selected site.	• The project is the construction of a fishing harbour will all necessary facilities for the landing and handling of daily catches at Ajanur, next to the existing Fish Landing Centre (FLC). • The proposed site is at equal distances from the existing fishing harbours at Kasaragod, at Cheruvattur (17 km towards the south of project site) and Kasaragod (17 km towards north of project site). • Hence, the site was identified as the best suited, given the concentration of fishers at Ajanur and its fishing potential, and no alternate sites were considered for this project.	Section 5.2 of Chapter 5
2.	Details of the land use break-up for the proposed project. Details of land use around 10 km radius of the project site. Examine and submit detail of land use around 10 km radius of the project site and map of the project area and 10 km area from boundary of the proposed/ existing project area, delineating project areas notified under the wild life (Protection) Act, 1972/ critically polluted areas as identified by the CPCB from time to time/ notified eco-sensitive areas/ interstate boundaries and international boundaries. Analysis should be made based on latest satellite imagery for land use with raw images.	• Land-use Land Cover Map of 10 km area is prepared with Q-GIS, using Landsat 08 data at 30 m special resolution. • As per LULC Map, 50.73 % of the study area is occupied with water bodies. 26.62 % is vegetation followed by Built-up Area (20.29 %). 2.05 % of the study area is cropland and 0.32 % is of sandy area are found within the 10 km study area. • There are no areas notified under the Wildlife (Protection) Act, 1972/ critically polluted areas as identified by the CPCB from time to time/ notified eco-sensitive areas/ interstate boundaries and international boundaries within 10 km radius of the proposed project site.	Section 1.7.2 of Chapter 1

S. No	Standard ToR	Compliance	Citation
3.	Submit the present land use and permission required for any conversion such as forest, agriculture etc. land acquisition status, rehabilitation of communities/ villages and present status of such activities.	• There is no land acquisition or R&R involved as the project is proposed in 'Puramboke' land owned by the government. • No forest land or agriculture land will be converted for the project.	Section 2.7.1 of Chapter 2
4.	Examine and submit the water bodies including the seasonal ones within the corridor of impacts along with their status, volumetric capacity, quality likely impacts on them due to the project.	• The project site is located in the perennial water bodies: Arabian Sea and Chithari River. • The average current velocity of the Chithari River near the mouth is 0.007 m/s during non-monsoon season and 0.015 m/s during the monsoon season. The average current in the Arabian sea at the proposed end of the river training breakwater, at the harbour entrance and inside the harbour is 0.43 m/s, 0.38 m/s, and 0.39 m/s respectively during the non-monsoon season and 0.55 m/s, 0.46 m/s and 0.49 m/s respectively during the monsoon season. • The quality of the marine water and marine sediment at these water bodies were monitored and according the anticipated impacts have been identified.	Table 2.3 of Chapter 2, Section 3.6.4 of Chapter 3, Section 4.4.2 and 4.5.2 of Chapter 4 and section 7.4 of Chapter 7.
5.	Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area.	• The contour map of 10 km study area is prepared using Digital Elevation Model (DEM), with an interval of 20 m along with slope map and drainage pattern. • As per DEM data, the highest elevation of study area is 185 m Above Mean Sea Level (AMSL) and lowest elevation is -7 m AMSL. • The slope ranged from 0 to 29°. • The area features dendritic drainage pattern of sea, rivers, canals and lakes.	Section 3.5.2 and 3.6.2 of Chapter 3.

S. No	Standard ToR	Compliance	Citation
6.	Submit the details of terrain, level with respect to MSL, filling required, source of filling materials and transportation details etc.	• Elevation map of 10 km prepared using DEM with 20.0 m contour interval shows that the highest elevation is 185 m AMSL and lowest elevation is -7 m AMSL. • Filling is required for foundation trenches of harbour facilities, which will be done through excess excavated earth or earth brought by the contractor. • Around 40 trucks are expected per day to bring construction materials to the harbour for the proposed constructions	Section 3.5.2 of Chapter 3. Table 4.3 of Chapter 4. Section 2.7.5 of Chapter 2.
7.	Examine road/ rail connectivity to the project site and impact on the existing traffic network due to the proposed project/ activities. A detailed traffic and transportation study should be made for existing and projected passenger and cargo traffic.	• The project has its access from a public road of width about 5 m that connects to the Kanhangad Kadappuram road junction. • From there it connects to the Palayi – Kanhangad Road – 0.85 km, SSE of southern breakwater, • which subsequently connects to State Highway (SH) 57. • During the construction phase, the traffic to the proposed site will be increased as about 40 trucks per day are estimated for the conveyance of construction materials to the site. • During the operation phase, it is estimated that about 80 vehicles, which includes trucks, auto-rickshaws, and 2 wheelers will be visiting the harbour to convey the daily catch to the customers and markets.	Table 2.2, Figure 2.4, and section 2.7.5 of Chapter 2.
8.	Submit details regarding R&R involved in the project.	There is no land acquisition and therefore R&R involved as the project is proposed in the government 'Puramboke' land next to the existing FLC.	Section 2.7.1 of Chapter 2 and Section 7.2 of Chapter 7.

S. No	Standard ToR	Compliance	Citation
9.	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale along with the recommendation of the SCZMA.	• NCESS prepared the CRZ Status Report and the HTL/LTL map in 1:4000 scale superimposing the project layout. • As per the CRZ mapping, the project site falls under CRZ IA, CRZ IB, CRZ II, CRZ-IV A, and CRZ-IV B.	Section 7.3 of Chapter 7.
10.	Submit the status of shore line change at the project site	• The major change in the shoreline of Ajanur is due to the shift of the river mouth. • From the Google Earth imageries, the shift in river mouth is very evident • Shoreline modeling studies were done by Central Water and Power Research Station (CWPRS) for the proposed alignment, which revealed that the northern side is expected to experience accretion, extending 2.5 km along the coast and 68 m seaward and the southern side is projected to erode, with a potential loss of 1.5 km along the coast and 40 m in cross-shore direction. It is observed that the shifting of the river mouth is about 0.2 km towards the north over a year.	Section 1.11 and Figure 1.1 of Chapter 1 Section 7.4 of Chapter 7
11.	Details of the layout plan including details of channel, breakwaters, dredging, disposal and reclamation.	• Construction of 425 m long south breakwater. • River training for the Chithari River through a 435 m long breakwater. • Development of landside facilities for the harbour with wharf & auction hall, shops, toilet facilities, Effluent Treatment Plant (ETP), solar panels, Rain Water Harvesting (RWH) tanks, smart infrastructural facilities, etc. • Creation of a 400 m long reclamation bund. • Dredging activities between the north breakwater and the river training structure at the Chithari River mouth.	Section 2.5 of Chapter 2

S. No	Standard ToR	Compliance	Citation
12.	Details of handling of each cargo, storage, transport along with spillage control, dust preventive measures. In case of coal, mineral cargo, details of storage and closed conveyance, dust suppression and prevention filters.	• The total fish landing capacity after the construction of the harbour is estimated to be 28,695 TPA. • The fishes will be brought to the harbour in fishing vessels of size 8 m, 10 m and 15 m. • About 80 vehicles, mainly trucks and auto-rickshaw, apart from few two wheelers are anticipated per day to transport the daily catch to nearby markets and consumers. • To control dust emissions from the vehicular movement, new paved internal roads and parking areas along with improvement of access roads are proposed.	Section 2.4, 2.7.5 and 2.9.4 of Chapter 2.
13.	Submit the details of fishing activity and likely impacts on the fishing activity due to the project. Specific study on effects of construction activity and pile driving on marine life.	• The unavailability of adequate fish landing facilities and difficulties in navigating the river mouth limits the number of fishing days. With the establishment of the fishing harbour, the number of safe fishing days at the proposed harbour is estimated to be 300 days. • The total fish handling capacity of the Ajanur harbour will be increased to a total of 28,695 TPA. • The proposed developments involve construction of breakwater, dredging and drilling of concrete piles for the wharfs and auction hall, which will create disturbance of bed sediment in water column. The impacts envisaged on marine water quality due to construction activities will be significant but temporary and reversible.	Section 2.4 of Chapter 2 and Section 4.4.5 of Chapter 4.
14.	Details of oil spill contingency plan.	• Non-motorized boats of 8 m length, motorized mechanical boats of 10 m length and motorized non-mechanical	Section 4.4.1 and 4.4.2 of

S. No	Standard ToR	Compliance	Citation
		boats of length 15 m will be operated at the Fishing Harbour and hence handling of oil is not envisaged at the harbour. • However, to manage accidental minor spill from the construction site, it shall be made sure that oil spill containment kits (including absorbent pads, absorbent socks, disposable bags, safety goggle etc.) are available at the construction site and shall be promptly used.	Chapter 4 and Section 10.3.2 and 10.8 of Chapter 10.
15.	Details of bathymetry study.	• The bathymetry of the proposed site with and without the proposed harbour was estimated using Acoustic Doppler Current Profiler (ADCP) by CWPRS.	Section 7.4 of Chapter 7.
16.	Details of ship tranquillity study	• Design of the breakwaters were done taking into consideration the following data to provide tranquil condition in the harbour: o Design Water Level (DWL) - 2.60 m (which is 1.20 m above the Mean Higher High Water) o Storm Surge of 0.80 m + Sea level rise of 0.40 m o Significant wave height of 4.0 m • This design ensures the breakwater's ability to provide tranquil conditions in the harbour, protecting it from strong wave action while minimizing overtopping and structural damage.	Section 7.5 of Chapter 7
17.	Examine the details of water requirement, impact on competitive user, treatment details, use of treated waste water. Prepare a water balance chart.	• During the construction phase, the water required for construction workers will be 4.5 kLD and for the construction activities will be 2 kLD. The water will be sourced from a nearby pump house and an open well outside the CRZ area. • During the operation phase, the fresh water requirement will be 16 kLD for cleaning of the fish handling area and	Section 2.7.2 and Section 2.9.1 of Chapter 2

S. No	Standard ToR	Compliance	Citation
		for domestic and flushing purposes of the operation workers. The water for the operation phase also will be sourced from the nearby pump house and open well, and harvested rainwater from the proposed RWH. • Water balance chart has been prepared and accordingly the wastewater generated from the project will be 15 kLD which will be treated in an ETP of capacity 15 kLD. • The treated water from the ETP will be recycled and used for landscaping.	
18.	Details of rainwater harvesting and utilization of rain water	• Rainwater Harvesting (RWH) tank of capacity 15 kLD is proposed to be provided at the landside facilities The harvested rainwater will used after filtration and disinfection, as a fresh water source for the operations at the harbour.	Section 2.7.2.1 of Chapter 2.
19.	Examine details of solid waste generation, treatment and its disposal.	• The dredged spoil remaining after reusing it for construction of the reclamation bund. • During construction phase, the solid waste generated by the construction workers is estimated to be 4 kg/day as biodegradable waste, which shall be managed using aerobic composting bins. The non-biodegradable waste generated by the workers will be 6 kg/day, which will be segregated at source to plastic, recycles, etc. and shall be timely handed over to recyclers. • During the operation phase, the solid waste generated by the operation staff will be 1.5 kg/day. All waste generated at the project shall be segregated at source and shall be managed by handing over to authorized recyclers/ handlers.	Section 2.9.3 of Chapter 2 and Section 10.3.3 of Chapter 10.

S. No	Standard ToR	Compliance	Citation
20.	Details of desalination plant and the study for outfall and intake.	Not applicable as desalination plant is not proposed in the Ajanur Fishing Harbour.	-
21.	Examine baseline environmental quality along with projected incremental load due to the proposed project/activities.	• The baseline quality of ambient air, noise levels, surface water, marine water, soil, and marine sediments were monitored. • The anticipate impacts on the baseline environments due to the proposed project have been evaluated and adequate mitigation measures have been suggested.	Chapter 3 and Chapter 4
22.	The air quality monitoring should be carried out according to the notification issued on 16th November, 2009.	The air quality monitoring has been carried out at 3 locations to measure the PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO	Section 3.7 of Chapter 3
23.	Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.	• The estimated budget for EMP is INR 18.00 lakhs as capital cost and INR 12.31 lakhs/year as recurring cost during construction phase. • During operation phase, the cost for EMP is estimated to be INR 16.00 lakhs/year. • Environmental Monitoring Plan have been developed which includes monitoring air, noise, soil, water, and marine environments. The budget for environmental monitoring for construction phase is estimated to be INR 2.46 Lakhs/year, and for the operation phase, is INR 2.85 Lakhs/year.	Chapter 10 and Chapter 6
24.	Submit details of a comprehensive Risk Assessment and Disaster Management Plan including emergency evacuation during natural and man-made disasters	• The project faces risks from natural hazards like coastal hazards, cyclones, floods, earthquake, drought, and lightning, in addition to anthropogenic hazards. These risks are assessed, and mitigation measures are proposed.	Section 7.6 of Chapter 7.

S. No	Standard ToR	Compliance	Citation
		• An Emergency Response Team will be formed to handle emergencies effectively. Contact information for relevant authorities and nearby emergency facilities shall be displayed on the site.	
25.	Submit details of the trees to be cut including their species and whether it also involves any protected or endangered species. Measures taken to reduce the number of the trees to be removed should be explained in detail. Submit the details of compensatory plantation. Explore the possibilities of relocating the existing trees.	No trees are proposed to be cut for the project.	Section 2.7.1 of Chapter 2
26.	Examine the details of afforestation measures indicating land and financial outlay. Landscape plan, green belts and open spaces may be described. A thick green belt should be planned all around the nearest settlement to mitigate noise and vibrations. The identification of species/ plants should be made based on the botanical studies.	• Landscaping and green area development of 3,000 m^2 is proposed along with the project. • This will be developed as a green belt of thickness 5 m. • The species such as Vaga, Ezhilamppala, Ariyaveppu, etc. shall be planted in the green belt.	Table 2.7, under Section 2.5.3 of Chapter 2 and Table 10.2 of Chapter 10
27.	The Public Hearing should be conducted for the project in accordance with provisions of Environmental Impact Assessment Notification, 2006 and the issues raised by the public should be addressed in the Environmental Management Plan. The Public Hearing should be conducted based on the ToR letter issued by the Ministry and not on the basis of Minutes of the Meeting available on the web-site.	This project does not fall under the purview of the EIA Notification of 2006 and therefore public hearing is not required.	Section 7.1 of Chapter 7.

S. No	Standard ToR	Compliance	Citation
28.	A detailed draft EIA/EMP report should be prepared in accordance with the above additional TOR and should be submitted to the Ministry in accordance with the Notification	The EIA report for the project was prepared in accordance with EIA Notification 2006 and its amendments. The study followed the Standard ToR for conducting EIA study for Ports and Harbours issued by the MoEF&CC and EIA guidance manual for Ports and Harbours. Additional ToR was not obtained for the project as it is not mandated as per CRZ Notification 2019.	Section 1.7 of Chapter 1.
29.	Details of litigation pending against the project, if any, with direction /order passed by any Court of Law against the Project should be given	No litigations or court orders pending against the land or proponent or project	Section 1.9 of Chapter 1
30.	The cost of the Project (capital cost and recurring cost) as well as the cost towards implementation of EMP should be clearly spelt out	The estimated project cost for the proposed project is INR 20,000 Lakhs. The estimated EMP budget includes a capital cost of INR 18.00 lakhs and recurring cost of INR 12.31 lakhs/year during construction phase. For the operation phase, the estimated cost for EMP is INR 16.00 lakhs/year.	Section 2.12 of Chapter 2 & Section 10.8 of Chapter 10
31.	Any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent can refer to the model ToR available on Ministry website "http://moef.nic.in/Manual/Port and harbour"	Noted	-

Chapter 1 Introduction

1.1 Purpose of the Report

The Harbour Engineering Department (HED) proposes the construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala. The fishing harbour is designed to have a fish handling capacity of 28,695 Tonnes Per Annum (TPA). The project attracts the Coastal Regulation Zone (CRZ) Notification 2019, as it falls in CRZ IA, CRZ IB, CRZ II, CRZ IV A and CRZ IV B and hence Environmental Impact Assessment (EIA) is required to assess potential environmental impacts, to propose mitigation measures, and formulate an Environmental Management Plan (EMP). ULTRA TECH has been entrusted by HED to prepare the EIA report for submission to the Kerala Coastal Zone Management Authority (KCZMA) to obtain CRZ clearance.

1.2 Identification of the Project Proponent

The HED of Government of Kerala is the project proponent. The details of the authorised signatory and the address for correspondence is given in Table 1.1.

Table 1.1: Details of Authorised Signatory and Address for Correspondence

Particulars	Descriptions
Address for correspondence	Office of the Executive Engineer, Harbour Engineering Kasaragod Division, Clock Tower Junction, Near Railway Station, Kasaragod, Kerala – 671 121
Email id	eekgd.hed@kerala.gov.in

1.3 Identification of the Project

The project is proposed to address the issues faced by the local fishing community and the fishery industry in the region, which operates near the Chithari River. Fishers at Ajanur currently face challenges in their day-to-day fishing activities due to the migratory nature and periodic closing of the Chithari River mouth, and inadequate fish handling facilities at the existing Fish Landing Centre (FLC). Existing FLC includes only a dilapidated auction hall, net mending shed and toilet block. The master plan for the project involves the following features:

- North and south breakwaters for establishing the harbour basin and river training wall.
- Landside facilities of the harbour which include wharf, auction hall, berthing wharf, canteen, net mending shed, shop rooms, locker rooms, gate and gate house, office cum surveillance room, Rain Water Harvesting, Effluent Treatment Plant (ETP), etc.
- For the stabilization of the river mouth, a river training wall on the north side of the mouth, dredging and reclamation is proposed in accordance with the modelling studies conducted by Central Water & Power Research Station (CWPRS), Pune.

1.4 Brief description of the nature, size and location of the project

Brief description of the project is given in Table 1.2.

Table 1.2: Brief Description of the Project

<table>
<tr><th>Particulars</th><th>Descriptions</th></tr>
<tr><td colspan="2">Location Details</td></tr>
<tr><td>Village & Panchayath</td><td>Ajanur</td></tr>
<tr><td>Taluk & District</td><td>Kasaragod</td></tr>
<tr><td>State</td><td>Kerala</td></tr>
<tr><td colspan="2">Project Details</td></tr>
<tr><td>Proposed features</td><td>• Northern breakwater of length 1,150 m
• Southern breakwater of length 425 m
• River training work of Chithari river in the form of a breakwater of length 435 m
• Reclamation bund of length 400 m
• Wharf of dimension 120 m × 6.6 m
• Auction hall of dimension 60 m × 15 m
• Dredging proposed in between the north breakwater and river training work at the mouth of Chithari river
• 2-story building including canteen, rest shed, locker room, gear shed
• Other buildings such as toilet block, workshop building, office room cum harbour surveillance camera room.
• ETP, RWH facility landscaping and green belt
• Mechanical conveyor system & Automation
• Electrification and Installation of Solar energy system
• Gate and Gate House with ATM and toll booth.
• Water supply arrangements in the harbour with overhead tank and sump
• Construction of wharf for berthing facility
• Navigational aid, pressure washer and cleaning equipment,
• Development of green area, approach road, internal road, parking area, drainage facility, compound wall and side protection work
• Development of smart infrastructure and automated systems</td></tr>
<tr><td>CRZ Zone</td><td><table>
<tr><th>CRZ Zone</th><th>Length (m)</th><th>Area (m^2)</th></tr>
<tr><td>CRZ IA</td><td>16.48</td><td>-</td></tr>
<tr><td>CRZ IB</td><td>187.68</td><td>11,181.91</td></tr>
<tr><td>CRZ II</td><td>719.08</td><td>3,636.97</td></tr>
<tr><td>CRZ IVA</td><td>749.14</td><td>44,911.33</td></tr>
<tr><td>CRZ IVB</td><td>-</td><td>94.60</td></tr>
<tr><td>Total</td><td>1,672.38</td><td>59,824.81</td></tr>
</table></td></tr>
<tr><td>Fish landing capacity</td><td>28,695 TPA</td></tr>
</table>

Particulars	Descriptions
Project cost	INR 20,000 Lakhs
Construction period	46 months

1.5 Importance of the Project to the Region and Country

The proposed project responds to a longstanding need for improved fishing infrastructure in Kasaragod District, where fishing is a primary livelihood. With a coastline of 70 km and an annual fish landing of 35,163 tonnes, the district heavily depends on the fishing industry. The migratory nature of the Chithari river mouth and absence of safe fish landing facilities pose life threatening conditions to the fishers bringing back their catch. The existing harbour consists only a dilapidated auction hall and a toilet block. These landside infrastructures lack adequate facilities for handling the catches and meeting the basic needs of fishers. The proposed harbour will provide safer fish landing and handling facilities and also benefit mechanized and traditional fishing in the area by providing modern infrastructure facilities, enhancing the safety and efficiency of fishing operations. The harbour will serve as a vital hub for nearby fishing villages, Hosdurg, Ajanur and Pallikkara, directly benefiting around 7,094 people involved in the fishing industry.

1.6 Scope of the EIA Study

EIA study for the proposed project has been undertaken based on EIA Notification, 2006 (amended thereof) from Ministry of Environment, Forest and Climate Change (MoEF&CC). This EIA report for the proposed fishing harbour is prepared as per the Standard Terms of Reference (ToR) for conducting EIA study for Ports and Harbours issued by the MoEF&CC, April 2015 and EIA guidance manual for Ports and Harbours prepared by Administrative Staff College of India.

1.6.1. Environmental Legislative Framework

Understanding of the applicable environmental legislation and guiding principles is crucial for the determination of compliance with the statutory requirements and environmental standards. The environmental legislation relevant to the project listed in Table 1.3.

Table 1.3: Environmental Legislative Framework

S No	Act/Rule /Notification Guidelines by MoEF&CC	Applicability (Yes/No)	Project specific applicability	Regulatory Authority
1.	The Wildlife (Protection) Act, 1972 and subsequent amendments	No	The project site does not come within 10 km boundary of any protected areas as per the Wildlife (Protection) Act	National Board for Wildlife (NBWL)
2.	Water (Prevention and Control of Pollution) Act, 1974 as amended	Yes	ETP is proposed in the landside facilities of the harbour. Consent to Establish (CTE) and Consent to Operate (CTO) from the Kerala State Pollution	KSPCB

S No	Act/Rule /Notification Guidelines by MoEF&CC	Applicability (Yes/No)	Project specific applicability	Regulatory Authority
			Control Board (KSPCB) is required.	
3.	Van (Sanrakshan Evam Samvardhan) Adhiniyam, 1980 and subsequent amendments	No	Forest Clearance is not required as the project does not involve any forest land	MoEF&CC
4.	Air (Prevention and Control of Pollution) Act, 1981 as amended	Yes	Air pollution control measures in the operation phase for the emissions from the Diesel Generator (DG) set and other machineries used. CTE and CTO from the KSPCB is required.	KSPCB
5.	Environment (Protection) Act, 1986 amended in 1991 and Environment (Protection) rules, 1986 as amended	Yes	No permit required, but rules shall be followed during the construction and operation phase, without any emission or discharge of any environmental pollutants in quantities exceeding the standards issued by KSPCB	MoEF&CC and KSPCB
6.	Noise Pollution (Regulation & Control) Rules, 2000	Yes	Machineries and vehicles used in the construction and operation phase to conform to the standards specified by KSPCB	KSPCB
7.	EIA Notification 2006 and subsequent amendments	No	The Schedule of S.O. 1533 dated 14.09.2006 issued by the MoEF&CC, depicts the 'list of projects or activities requiring prior EC'. As the fish handling capacity of the proposed fishing harbour will be 28,695 TPA, which is less than the threshold limit of 30,000 TPA as amended in the EIA Notification 2006 vide S.O. 3194 (E) dated 14.07.2022, EC is not required for the project	SEIAA or MoEF&CC

S No	Act/Rule /Notification Guidelines by MoEF&CC	Applicability (Yes/No)	Project specific applicability	Regulatory Authority
8.	Solid Waste Management Rules, 2016	Yes	Rules shall be followed for the segregation, storage, handing over and disposal of solid waste.	KSPCB
9.	Construction & Demolition (C&D) Waste Management Rules 2016	Yes	The C&D waste generated from the construction of landside infrastructure shall be managed as per the said rules.	KSPCB
10.	Hazardous and other Wastes (Management and Trans boundary Movement) Rules, 2016 as amended	Yes	Rules shall be followed for the safe storage of used oil from diesel engines of fishing vessels. Hazardous wastes shall be handed over to authorized dealers.	KSPCB
11.	Plastic Waste (Management and Handling) Rules, 2016 and its amendments	Yes	Segregation of plastic waste generated like fishing nets, etc. and handover to recyclers. Use of banned plastic products shall be strictly avoided.	KSPCB
12.	Coastal Regulation Zone (CRZ) Notification 2019 and subsequent amendments	Yes	Project site falls within CRZ IA, CRZ IB, CRZ II, CRZ-IV A and CRZ-IV B. Hence CRZ Clearance is required.	KCZMA
13.	E-waste (Management) Rules, 2022	No	No generation of E-waste anticipated.	KSPCB
14.	Batteries Management and Rules, 2022	No	No use of lead acid batteries	KSPCB

As per the amendment to the CRZ Notification 2019, dated 28th November 2014, the authority for issuing CRZ Clearance for projects not attracting the EIA notification 2006 is SEIAA, unless it is an activity listed under paragraph 4 (ii) of the CRZ Notification 2019. The CRZ Clearance for the proposed project is to be obtained from SEIAA, Kerala after obtaining recommendations from KCZMA.

1.7 Status of Litigations/ Court Orders: Land & proponent

There are no litigations or court orders pending against the land or the project

1.8 Site History

From DPR prepared by HED, desktop study using Google Earth Pro (from the year 2011 to 2025) and consultation with the local people, the details regarding the site's history were gathered. It is revealed that the Chithari river mouth is of migratory nature. The Google Earth imagery showing the shifting of the Chithari river mouth at different years is shown in Figure 1.1.

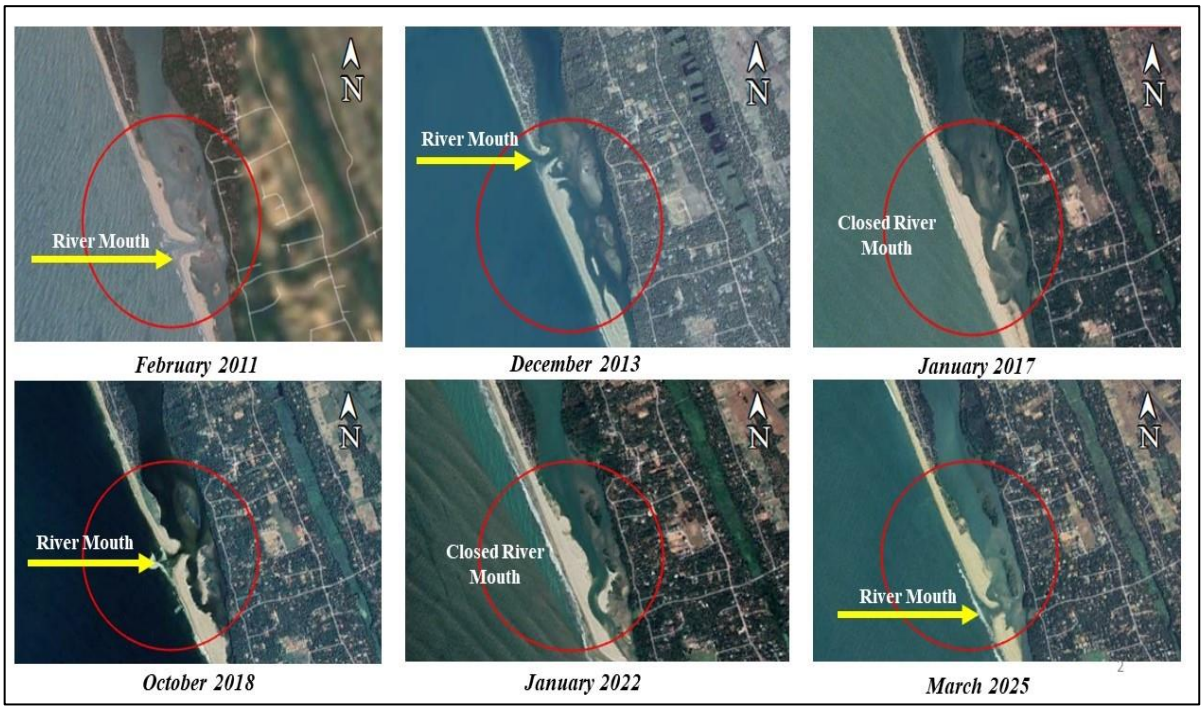


Figure 1.1: Google Earth Imagery showing shifting of Chithari River mouth

The following observations are made from the Google Earth imagery:

- Google earth imagery from February 2011 to March 2025 shows that the river mouth is migratory in nature, making it difficult for fishermen to navigate
- Imagery dated January 2017 & January 2022 shows that the river mouth is completely closed, preventing fishermen from accessing the sea and severely impacting their fishing activities
- Imagery of December 2013 and October 2018 shows the river mouth opened towards the sea, but its intricate shape and sand bars caused fishermen to face extreme danger and damage to existing auction hall
- In present year, the river mouth is shifted towards the north, showing the migratory nature of the Chithari river mouth

Chapter 2 Project Description

2.1 Type of Project

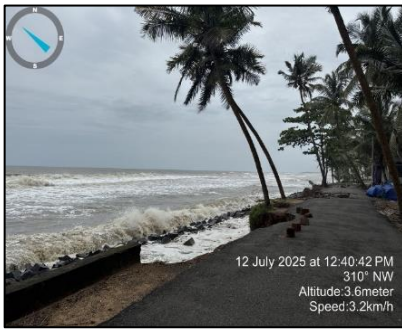
The proposed Ajanur Fishing Harbour project entails constructing an open-sea harbour with north and south breakwaters along with a river training wall to stabilize the migratory Chithari river mouth and prevent sandbar formation, mitigating associated risks to human life and property of the fishers. Additionally, the project encompasses the development of onshore infrastructure to support the fishing community by providing wharf and auction hall, berthing wharf, canteen, net mending shed, shop rooms, locker rooms, gate and gate house, office cum surveillance room, ETP etc.

2.2 Need and Justification of the Project

- Sand bars at Chithari River mouth endanger fishermen, causing loss of life and vessel damage. Over 500 fishing vessels experience significant challenges in navigating the area.
- Southward shift of the river mouth has damaged auction hall and existing roads. Therefore, new auction hall is planned to be built for providing a designated space for fishermen to sell their catch.
- Existing fish landing centre lacks berthing facilities, leaving boats and equipment on the beach, where they risk damage or being washed away. To address this, wharfs are proposed for safe landing, berthing and vessel repairs.
- By constructing northern and southern breakwaters and river training wall, the Chithari River mouth can be stabilized, preventing its closure during the summer months. This will mitigate the risk of flash floods and safeguard both coastal and upstream communities, along with providing sheltered and calm basin for the landing of the boats.
- For the safe storage of the tools and equipment of the fishers, locker rooms, office room cum harbour surveillance camera room, gate and gate house, etc. will be provided. All other necessary landside facilities are proposed in the harbour to ensure uninterrupted fishing operations.
- The enhanced infrastructure facilities can meet the growing demands of the fishing community and maintain hygienic standards and encourage sustainable fishing practices as outlined by the Food and Agriculture Organization (FAO).

The photographs showing need for the project is given in Figure 2.1.





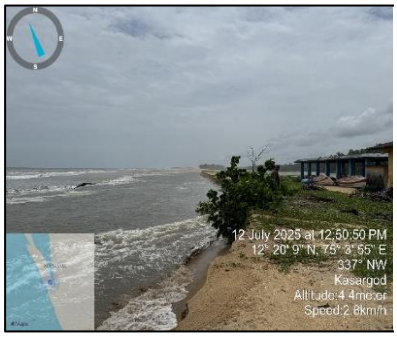




Figure 2.1: Need for the project

2.3 Location and Layout

The details of the location of proposed project site are given in Table 2.1.

Table 2.1: Location details of Proposed Project Site

S. No	Aspects	Details
1.	Geographical Co-ordinates of proposed facilities	Northern breakwater: 12°20'11.66"N, 75° 3'53.04"E Southern breakwater: 12°19'55.64"N, 75° 3'58.95"E River training works: 12°20'17.39"N, 75° 3'51.34"E Fishing Harbor facilities: 12°20'10.18"N, 75° 3'54.87"E
2.	Village	Ajanur
3.	Taluk	Kasaragod
4.	District	Kasaragod
5.	State	Kerala

The index map for the proposed project location is given in Figure 2.2.

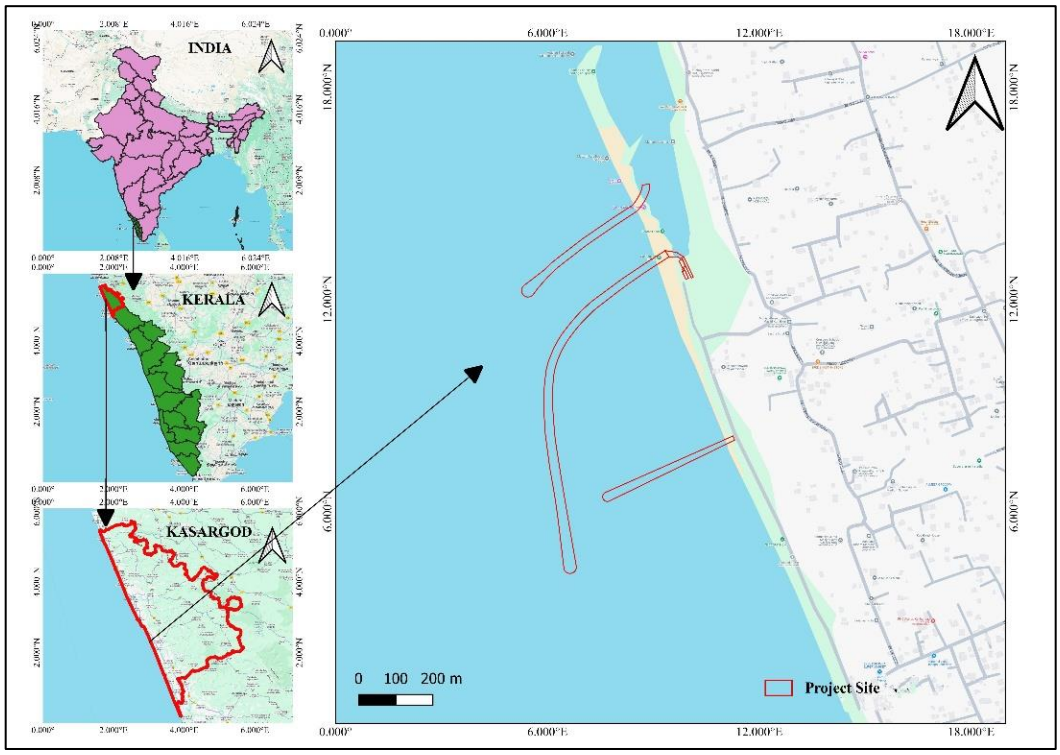


Figure 2.2: Index Map of the Proposed Project Site

Google Earth imagery of the project location is shown in Figure 2.3.



Figure 2.3: Google Earth Imagery of the Project Location

The proposed project site is at a distance of 2.4 km from State Highway (SH) 57 (Kasaragod – Kanhangad Highway). The access road to project site has a width of around 5 m. Existing FLC can be directly accessed from this public road. The Crescent Road and Palayi - Kanhangad Road links the

access road with SH 57. It is proposed to renovate the internal roads and approach road to the proposed fishing harbour facilities. The connectivity to the proposed project site is shown in Figure 2.4.

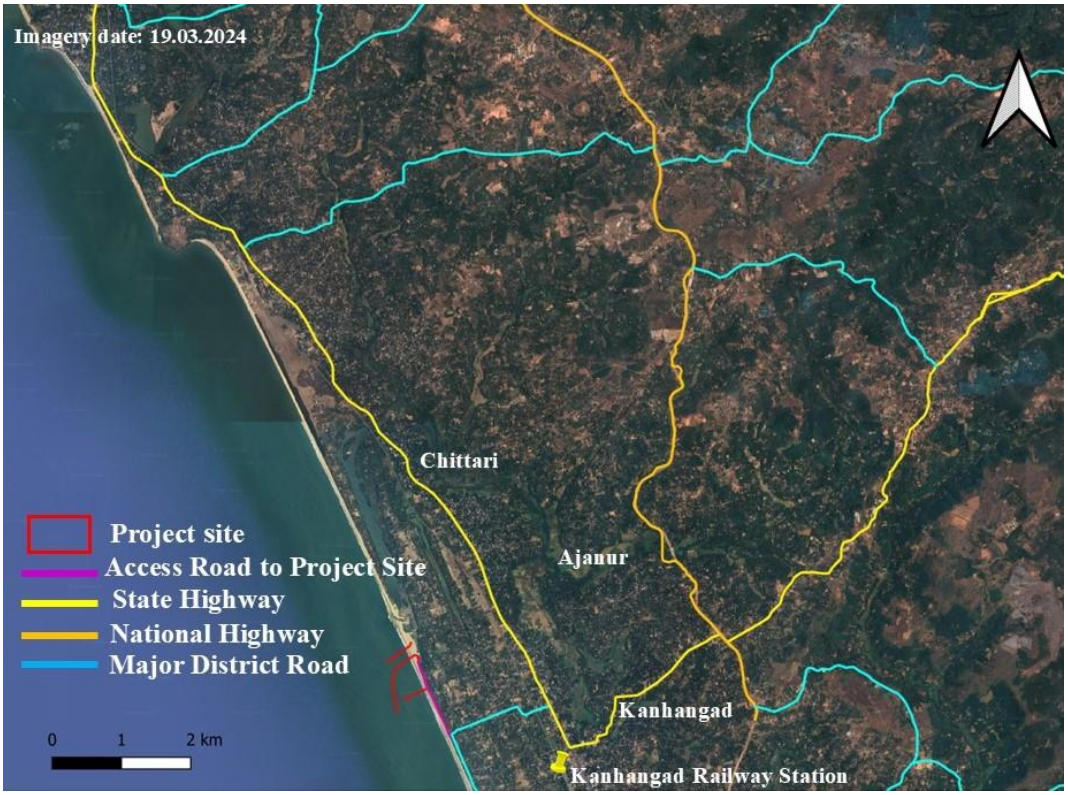


Figure 2.4: Connectivity Map of Project Site

A brief of the connectivity to the project site is given in Table 2.2.

Table 2.2: Connectivity to the Proposed Project Site

Particulars	Details with road distances
Nearest Roads	• Approach Road: Road connecting Kanhangad Kadappuram road junction to the existing FLC • Palayi – Kanhangad Road – 0.85 km, SSE of southern breakwater
Nearest Highways	• SH 57 – 2.4 km, E of southern breakwater • National Highway (NH) 66 – 5.6 km, E from southern breakwater
Nearest railway station	Kanhangad Railway Station - 4 km, SE from southern breakwater
Nearest Airport	Kannur International Airport– 88 km, SE from southern breakwater
Nearest town/City	Kanhangad – 4 km SE from southern breakwater.
Densely populated area	Kanhangad – 4 km SE from southern breakwater.

The environmental setting 10.0 km study area is given in Table 2.3.

Table 2.3: Environmental Setting within 10.0 km Study Area

S. No.	Item	Details
1.	Major water bodies	• Lakshadweep Sea - 0 km, SW from Southern Breakwater • Chithari River – 0 km, NNW from Northern Breakwater • Pulluru stream – 4.7 km, NE from from Southern Breakwater • Chemmattam vayal wetlands – 5.21 km, ESE from Southern Breakwater • Karingode River- 6.17 km, ESE from Southern Breakwater • Madikkai stream- 6.5 km, SE from Southern Breakwater • Vazhakkodchal – 6.70 km, SE from Southern Breakwater
2.	Reservoirs/dams	Nambiarkal dam - 9.09 km, SE from Southern Breakwater
3.	Ecologically sensitive areas; Important Coastal & Marine Biodiversity Areas (ICMBAs), Biodiversity Heritage Site*.	None within 10 km study area
4.	Protected areas as per the Wildlife Protection Act (Tiger reserve, Elephant reserve, Biospheres, National parks, Wildlife sanctuaries (WLS), community reserves, and conservation reserves)	
5.	Reserved / Protected / Forests	
6.	Unique or threatened ecosystem	
7.	Notified groundwater zone by CGWA	Safe (Chirayinkeezhu Taluk)
8.	Critically environmental polluted area	None within 10 km radius
9.	Coastal areas rich in corals, mangroves, breeding grounds of specific species	
10.	Estuaries rich in mangroves, breeding ground of specific species	
11.	Historically important places	Bekal Fort – 7.1 km, NW from Northern Breakwater
12.	Hazard Zones as per the Landslide Susceptibility Zonation Map issued by KSDMA	Low Hazard Zone: 6.5 km, E from Northern Breakwater Medium Hazard Zone: None within 10 km radius High Hazard Zone: None within 10 km radius

S. No.	Item	Details
13.	Seismicity	The proposed project site is in Seismic Zone III as per IS: 1893.

** Total of 106 coastal and marine sites have been identified and prioritized as Important Coastal and Marine Areas (ICMBAs) by Wildlife Institute of India (WII).* [2]**.**

The social setting of 10.0 km study area is given in Table 2.4. It was noted that defence installation and major industries are not present within 10.0 km study area.

Table 2.4: Social Setting within 10 km Study Area

S. No.	Item	Distance	Direction
Hospitals			
1.	Family Health Centre, Ajanur, Kanhangad	0.73 km	SSE from Southern breakwater
2.	New Life Maternity Hospital, Athinhal	1.39 km	NE from Northern breakwater
3.	Kerala Hospital, Athinhal	1.54 km	ENE from Southern breakwater
Schools			
1.	Crescent School, New Building, Kothikkal	0.32 km	NE from Southern breakwater
2.	Sree Kurumba English Medium School	0.44 km	SE from Southern breakwater
3.	G.F.U.P.S Ajanur Kadappuram - School	0.75 km	SE from Southern breakwater
Colleges			
1.	SISS College of Arts and Science, Kanhangad	1.80 km	NNE from Northern breakwater
2.	Navabharath Science College, Kanhangad	2.19 km	ESE from Southern breakwater
3.	Universal College, Kanhangad	2.21 km	SE from Southern breakwater
Temple			
1.	Sree Kurumba Bhagavathy Temple	0.33 km	SE from Southern breakwater
2.	Kolavayal Sree Rajarajeshwari Temple	0.58 km	ENE from Northern breakwater
3.	Adimayil Sree Shaktheya Devi Temple	1.00 km	ENE from Northern breakwater
Church			
1.	Elohim Christ Church Kanhangad	2.0 km	ESE from Southern breakwater
2.	Pioneer Missionary Church, Kanhangad	2.13 km	SE from Southern breakwater
3.	Infant Jesus Forane Church, Kanhangad	2.59 km	SE from Southern breakwater
Mosque			
1.	Muhiyudheen Juma Masjid Kothikkal	0.33 km	NNE from Southern backwater
2.	Muttumthala Juma Masjid, Muttumthala	0.99 km	NNEE from Northern backwater
3.	Sidiqual Bilal Masjid, Ettammal	1.03 km	ESE from Southern backwater

2.4 Size/ Magnitude of the Project

The salient features of the proposed project and the magnitude are given in Table 2.5.

([2]) wiienvis.nic.in/Database/ICMBAs_8247.aspx

Table 2.5: Salient Feature of the Proposed Project

<table>
<tr><th>Particulars</th><th>Description</th></tr>
<tr><td>Proposed constructions</td><td>• Northern breakwater of length 1,150 m
• Southern breakwater of length 425 m
• River training work of Chithari river in the form of a breakwater of length 435 m
• Landside facilities for the harbour
• Reclamation bund of 400 m length.
• Dredging in between the north breakwater and river training work at the mouth of river Chithari</td></tr>
<tr><td>Fish landing capacity</td><td>28,695 TPA</td></tr>
<tr><td>Details of fishing vessels</td><td>
<table>
<tr><th>Overall Vessel Length (m)</th><th>No. of Vessels</th><th>Fishing Trip (Days)</th><th>Fishing Trips per Year</th><th>Average Daily Landing (kg)</th><th>Fish Landing Capacity/Year (kg)</th></tr>
<tr><td>8</td><td>30</td><td>1</td><td>220</td><td>50</td><td>3,30,000</td></tr>
<tr><td>10</td><td>50</td><td>1</td><td>150</td><td>700</td><td>52,50,000</td></tr>
<tr><td>15</td><td>553</td><td>1</td><td>44</td><td>950</td><td>2,31,15,400</td></tr>
<tr><td colspan="5">Total</td><td>2,86,95,400</td></tr>
</table>
</td></tr>
<tr><td>Period of construction</td><td>46 Months</td></tr>
<tr><td>Beneficiary population</td><td>• Local population in 3 fishing villages; Hosdurg, Ajanur and Pallikkara.
• Beneficial for 7,094 people with 2,138 registered fishermen</td></tr>
</table>

2.5 Project Description

The project outlines the construction of a new open sea fishing harbour in Ajanur to address the fisher's infrastructure needs and the challenges posed by the Chithari River's migratory nature. The details of proposed facilities in the are given in Table 2.6.

Table 2.6: Proposed Infrastructure Facilities

S. No.	Component	Details
1.	Northern breakwater	1,150 m
2.	Southern breakwater	425 m
3.	River training wall	435 m
4.	Reclamation bund	400 m
5.	Wharf	120 m × 6.6 m
6.	Auction hall	60 m × 15 m
7.	Approach road	950 m × 5.5 m
8.	Internal road	740 m × 4 m
9.	Parking area	4,320 m^2

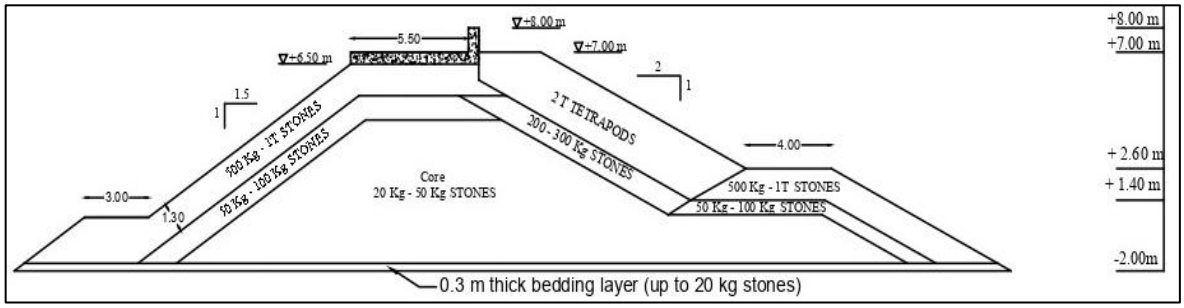
S. No.	Component	Details
10.	Office room cum harbour surveillance camera room	14.6 m × 22.6 m (2 storey)
11.	Work shop building	9.8 m × 9.8 m
12.	Gate House with ATM counter and toll booth	2.4 m × 2.4 m
13.	Wharf for berthing facility	100 m × 5 m
14.	Canteen, Rest Shed, Locker Room, Gear Shed	45 m × 10 m (two storey)
15.	Compound wall	510 m
16.	Side protection work	1,710 m
17.	Toilet Block	13.3 m × 5 m
18.	Net mending shed	23.2 m × 10 m

2.5.1. Proposed Breakwater for the Harbour

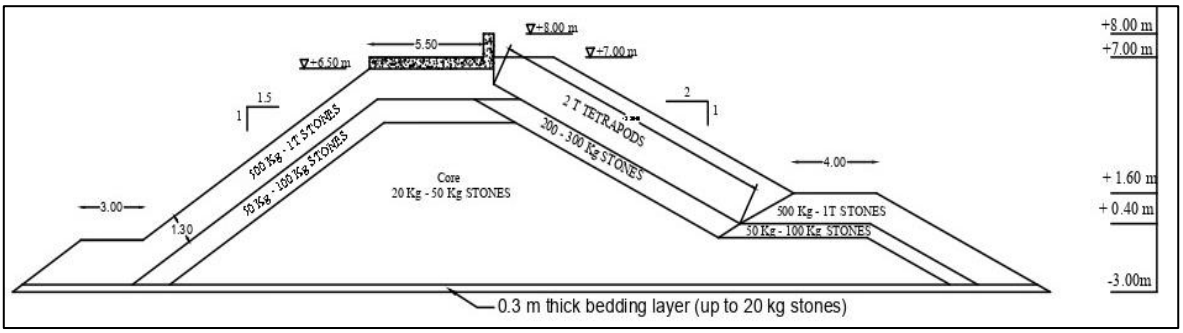
The final layout of the fishing harbour was decided based on the Modelling study report of CWPRS, Pune. The study recommended to construct 2 rubble mound breakwaters of length 1,150 m at the northern side and 425 m at the southern side to from a tranquil basin for the fishing harbour.

Crest width of 6.0 m at trunk and 9.0 m at head will be provided for the breakwaters. 5 kg to 20 kg category stones of approved quality will be used for the filter layer. Core of the breakwater will be constructed using 20 to 50 kg and 20 to 100 kg category stones. Stones of 50 to100 kg, 100 to 200 kg, 200 to 300 kg, 500 kg to 1 T category are proposed for secondary armour. For berm or scour protection stones of 2 to 3 T and 500 kg to 1 T category will be used. Tetrapod of 2 T and 6 T will be provided at sea side trunk portion and 8 T tetrapod will be provided at round head. At the leeward side 500 kg to1 T and 1 T to 2 T category stones are proposed for the primary armour layer. The tip of proposed breakwater lies at - 4.5 m depth of the sea.

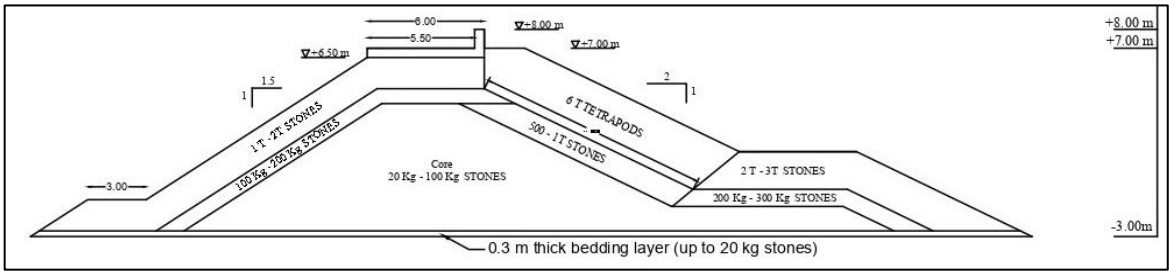
The cross-section details of the breakwater structures are given in Figure 2.5.



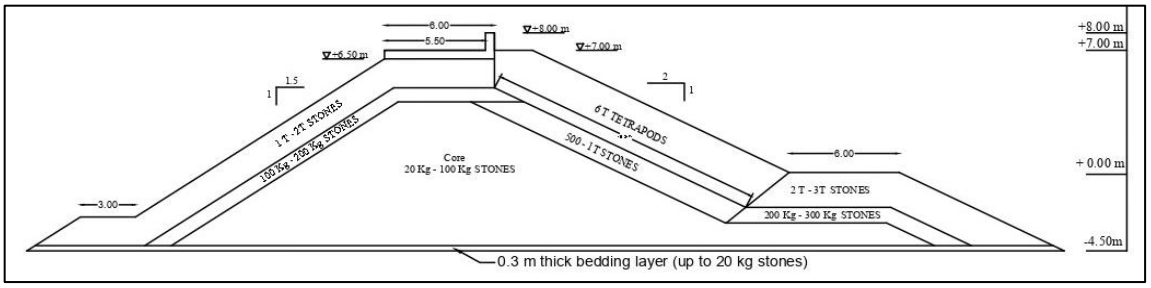
Trunk section at - 2.0 m bed level



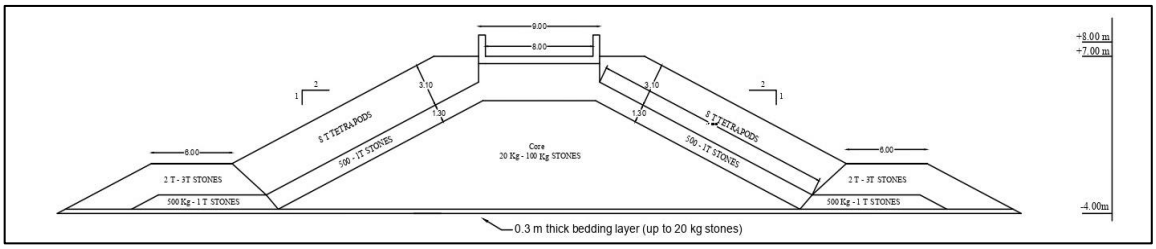
Trunk section at - 3.0 m bed level



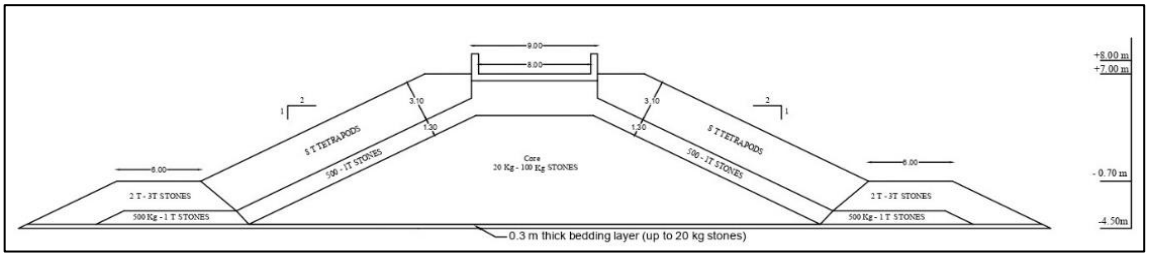
Trunk section at - 3.0 m bed level



Trunk section at – 4.5 m bed level



Round Head section at - 4.0 m bed level



Round Head section at - 4.5 m bed level

Source: DPR

Figure 2.5: Cross section of Breakwater

2.5.2. Proposed River Training Work

River training work of Chithari River in the form of a breakwater of length 435 m is proposed. River training work is proposed considering two major coastal processes: control of shifting and closing of Chithari River mouth due to sedimentation and southward littoral drift and littoral zone consideration. 5 kg to 20 kg category stones of approved quality is proposed for the filter layer. Core of the breakwater is using 20 to 50 kg and 20 – 100 kg category stones are proposed. Stones of 50 -100 kg,100 -200 kg, 200 - 300 kg, 500 kg - 1 T category are proposed for secondary armour, 2 to 3 T and 500 kg - 1 T category stones for berm or scour protection and 2T, 6T tetrapod at sea side at trunk portion and 8T tetrapod at round head is proposed. At the leeward side 500 kg - 1T and 1T - 2T category stones are proposed category stones for the primary armour layer. Crest width of 6.0 m at trunk and 9.0 m at head is provided.

2.5.3. Proposed landside facilities

The details of proposed facilities of the fishing harbour are given in Table 2.7.

Table 2.7: Proposed facilities for the fishing harbour

S. No	Particulars	Details
1.	Reclamation Bund	• Reclamation Bund is proposed along the basin for a length of 400 m. • Geotextile membrane will be laid along the bund (120 g/m^2 membrane) in two layers.
2.	Wharf and Auction Hall	• 120 m long wharf with a width of 6.60 m for 60 m length and 5.00 m width for remaining 60 m length is provided for landing, berthing, and repair of fishing vessels. Auction hall is of size 60 x 15 m is proposed on the rear side of the quay wall along landing area. • Bored cast-in-situ concrete piles of 750 mm diameter and 27.35m length is proposed as foundation for wharf.
3.	Canteen, Rest shed, locker room and gear shed	• Two storied building of size 45 m x 10 m is proposed to accommodate the facilities. • Net mending shed of size 23.2 m x 10 m is proposed in the ground floor. • 5 locker rooms and 5 shop rooms of size 3.10m x 3.50 m size is proposed in the ground floor. • A canteen of size 23.2 m x 10 m is proposed in the first floor along with 10 rest rooms of size 3.10m x 3.40 m. Head room of height 300cm is proposed. • Concrete isolated column footing over coconut piling and rubble packing is proposed as the foundation of structure.
4.	Compound wall & side protection works	• Compound wall with laterite stone of size 30x20x20 cm is proposed. The side protection works with foundation of

S. No	Particulars	Details
		coconut piling work with 30 cm thick and 80 cm wide dry rubble masonry above it. Superstructure of side protection work is proposed in gabion structure with mechanically woven double twisted hexagonal shaped wire mesh gabion boxes along with geo-textile filter between pitching and embankment slopes, to prevent escape of the embankment material through the voids of the stone pitching.
5.	Gate and Gate house	• Gate and gate house are proposed to ensure security to the harbor and to facilitate toll collection. • Toll booth and ATM counter of size 2.4 x 2.4 m each is proposed along with the gate house.
6.	Internal Roads and Parking Area and Drainage Facility	• Two-way internal road of width 4 m will be provided • Parking area of 4,320 m^2 will be provided • Covered drain with concrete PCC bed, side walls and guard stone will be provided
7.	Toilet Block	• Toilet block including 4 water closets, counter room cum cloak room, courtyard, bath area and wash area will be provided
8.	Approach Road	• Construction of approach road over a length of 950 m with 5.50 m width is proposed. • Proposed road connects Kanhangad Kadappuram road junction and proposed harbor. • The existing road is partially damaged with 4 m width.
9.	Work shop building	• Two storied building with 9.8 m x 9.8 m is proposed for work shop building. • The building contains office room (1.75 x 3m), shop (3 x 3m), toilet (1.05 x 1.2m), an electrical workshop (3 x 3m), a mechanical workshop (3 x 3m), a crane facility and a workspace (3 x 9.4m).
10.	Construction of office room cum harbour surveillance camera room	• A two storied building is proposed for office and Harbor surveillance camera room having a plinth area of 299.2 m^2. • Ground floor includes office room, store room, rest room, 3 toilet, porch, entrance, stair room, and an open area for cabins. • First floor contains an additional store room.
11.	Overhead and sump tank	• Overhead RCC water tank and sump of capacity 100 kL is proposed • A pump house will be constructed at the bottom of RCC tank • RCC sump of 50 kL capacity is proposed

S. No	Particulars	Details
12.	Electrification and Installation of Solar energy system	Proposed to set up facilities for electrification and installation of solar energy system.
13.	Berthing wharf	Berthing wharf of length 100 m and width 5m is proposed to be constructed near the south breakwater.
14.	ETP, Navigational Aid, Pressure Washer and Cleaning Equipment, Landscaping, Green Belt and Rainwater Harvesting, Mechanical conveyor system & Automation	• Mechanical conveyor system & Automation, ETP, Rainwater harvesting, pressure washer and cleaning, and navigational aid proposed. • Green area of 3,000 m^2 is proposed and it will be provided as a green belt of thickness 5 m.

Source: DPR

2.5.4. Proposed Dredging activities in the harbour

Dredging is proposed in the basin channel having average width 130 m and length 510 m. Dredging is also proposed in between the north breakwater and river training work at the mouth of River Chithari on an average 100 m width and 350 m length. It is proposed to dredge the area to a level of -3.0m. The total quantity of dredging proposed is 1,32,500 m^3. About 50% of the dredged spoil will be reused to the construction of the reclamation bund.

2.5.5. Proposed Smart Infrastructures in the Harbour

Smart infrastructure is proposed in the Ajanur Fishing Harbour using advanced technologies to improve efficiency, safety, and transparency in operations. Key features include:

- Digital Information Dissemination - Setting up a website and digital platforms to share information on auctions, harbour services, and fishery details, ensuring transparency and accessibility.
- Electronic Auctions - Implementation of local and online electronic auctions for efficient and fair trade, enabling global buyer participation without physical presence.
- Automated Sorting and Grading Systems - Use of machines to sort and grade fish by species, size, and quality, reducing manual effort and improving accuracy.
- Electronic Records for Sales and Resource Management - Maintaining digital records of catches, sales, and traceability to ensure efficient management and compliance with regulatory requirements.
- Hygiene and Safety Management - Introduction of automated entry/exit systems for vehicles and personnel, with hygiene checks integrated, to maintain safety and cleanliness standards.
- CCTV and Surveillance Systems - Installation of cameras for real-time monitoring of harbour activities, enhancing operational safety and security.
- Weighing and Cataloguing Systems - Advanced terminals and RFID-tagged systems for accurate weighing and easy creation of detailed sales catalogues.

- Hazard Analysis Critical Control Points (HACCP) System Integration - Facilitating electronic recording and monitoring of hygiene compliance at critical control points to uphold food safety standards.
- Traceability Enhancement - Digital traceability from catch to consumer through labels, QR codes, and electronic documentation for ensuring sustainability and quality assurance.

2.6 Technology and Process Description

The structure opted for the river training works and formation of tranquil river basin are rubble mounded breakwaters with tetrapod. Granite stones of size 10 kg to 3T and tetrapod of 2T, 6T and 8T will be used for the construction of the breakwaters. The alignment of the breakwater structures was finalized based on the recommendations of the model study by CWPRS.

RCC structures with strong foundation will be provided for the proposed harbour facilities at shores. Concrete beams, slabs and pillars will be made with optimized design considering the environmental conditions of the project area.

2.6.1. Feasibility Drawing

The schematic representations of the feasibility drawings which give information important for EIA purpose is given in Figure 2.6.

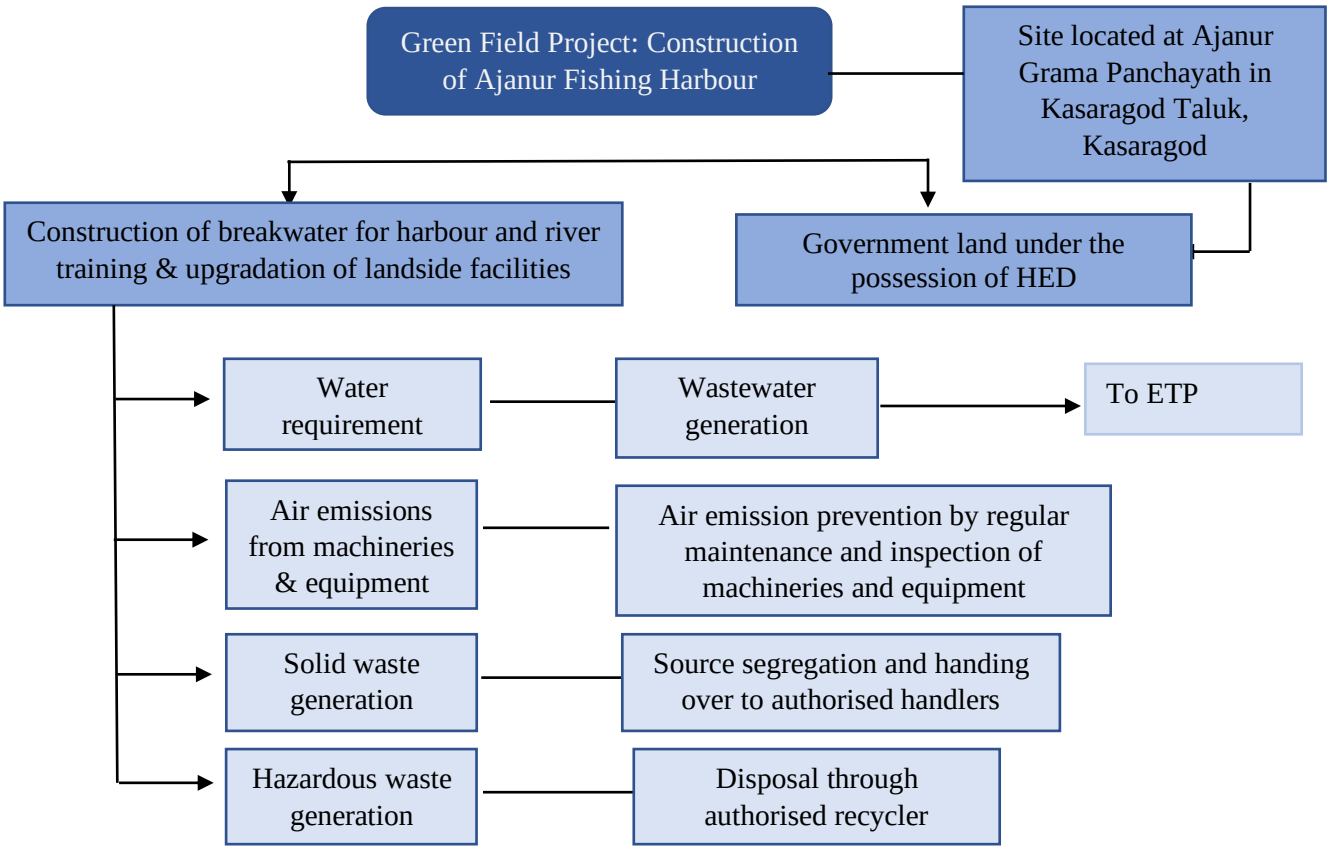


Figure 2.6:Feasibility Drawing

2.7 Resource Requirement for the Project

2.7.1. Land requirement

The proposed project will be constructed in the government Puramboke land available next to the existing FLC. No land acquisition and therefore no Rehabilitation and Resettlement (R&R) is required for the project. Also, no trees are proposed to be cut for the proposed constructions.

2.7.2. Water Requirement

The water requirement during the construction activities is 6.5 kLD; 2 kLD for construction activities and 4.5 kLD for construction workers (2.5 kLD for domestic purposes and 2 kLD for flushing requirements). The water will be sourced from a nearby pump house and an open well outside the CRZ area.

During the operation phase, the total water requirement is 16 kLD, which will be used for handling area washing and for worker demands. A detailed water balance chart for the proposed project is given in Figure 2.7.

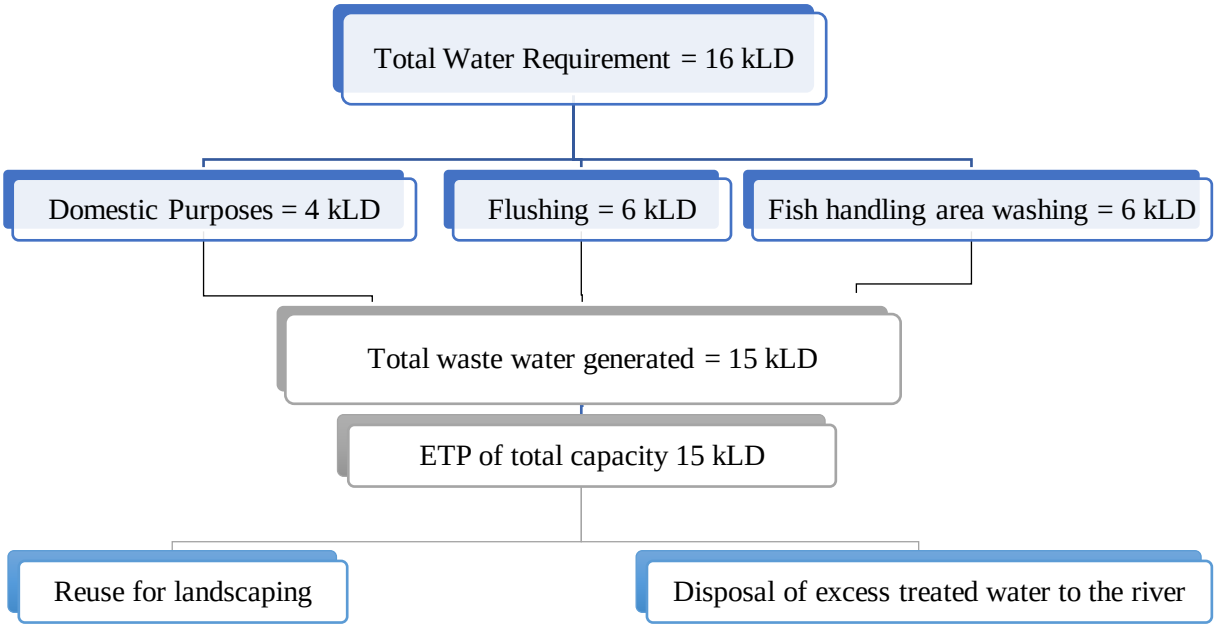


Figure 2.7: Water Balance Chart for the operational phase of the Proposed Project

The total water requirement for the project is 16 kLD, which will be sourced from the nearby pump house and open well. Additional water, if required, will be bought in tankers. The environmental impact of fresh water requirement is measured by a blue water footprint of 4847 kL per annum, considering fishing days equivalent to 10 months will be available for the fishing activities and operations of the harbour after achieving the safe fishing conditions.

2.7.2.1. Harvested Rainwater

It is proposed to provide Rainwater Harvesting tank of capacity 50 kL. The harvested water will be used as a source of fresh water at the harbour after filtration and disinfection. This will in-turn reduce the water footprint of the project.

2.7.3. Power Requirement

The power requirement for the construction phase will be 5 kVA, for which a temporary connection from Kerala State Electricity Board (KSEB) will be obtained. During the operation phase, all electrical installations in the harbour will be powered from solar energy. Solar panels of capacity 30 KW will be installed, which will satisfy the power requirement of 30 KW in operational phase. 1 DG set of capacity 30 kVA will be used as source of backup power for emergency situation.

2.7.4. Workforce Requirement

The workforce required for the proposed construction activities are estimated to be 100 workers/day as direct employees. The project will also provide indirect employment to about 200 workers/ day. The workforce requirement will be met as far as possible from the local population, depending on their skillset and knowledge. During the operation phase, about 15 workers will be employed at the harbour facilities.

2.7.5. Transport Infrastructure

The project sites for the construction of the fishing harbour. The nearest National Highway (NH) is NH–66, which is at a road distance of about 6.5 km (E). The nearest State Highway (SH) is SH–57 which is 2.9 km away from the site.

During the construction phase, about 40 trucks are expected per day to bring construction materials to the site. During the operation phase, for the smooth management of the vehicles carrying workers to the harbour and trucks transporting the catch from the harbour, adequate internal roads will be provided. A 4 m two-way internal road system is proposed to accommodate various type of vehicle entering and leaving the fishery harbour. An area of 4,320 m^2 is proposed for parking. About 80 trucks are anticipated per day into the harbour to transport the daily catch to nearby markets and consumers.

2.8 Aspects of the Project Likely to Cause Environmental Impact

The requirement of huge quantities of granite stones and tetrapod for the construction along with the conveyance and unloading of these materials at the site are the major environmental impacts anticipated due to the project. It shall be made sure that the quarry sourcing the granites stones and aggregates for the tetrapod possess valid EC and all other statutory clearances.

During the operation phase of the project, the increased fish landing days and increased fish landing capacity will lead to higher requirement of natural resources like fresh water and need for proper management of the waste generating from the site.

2.9 Management of wastes and emissions for the Project

2.9.1. Wastewater Management

Wastewater estimated to be generated by the construction workers is about 4 kLD. During the operation phase, the wastewater estimated to be generated from the operations of the harbour is about 15 kLD and for the management of wastewater generated from the harbour facilities, ETP of 15 kLD is proposed.

2.9.2. Storm Water Management

Storm water drain network is proposed for the project. Drains of length 364 m will be laid around the proposed parking area, having a depth of 0.6 m. Drains of length 57 m having a depth of 1 m will be provided to direct the storm runoff into the river. The width of the drains will be 1 m. The drains will have concrete Plain Cement Concrete (PCC) bed, side walls, cover slabs and 5 cm thick levelling course. Guard stone of 0.15 m height is proposed on the side of drainage.

2.9.3. Solid and Hazardous Waste Management

During the construction phase, the total solid waste generated by the construction workers is estimated to be 10 kg/ day, out of which, 4 kg/day will be biodegradable waste and 6 kg/day will be non-biodegradable waste.

The dredged spoil remaining after reusing it for construction of the reclamation bund will be disposed beyond 3 km and up to 5 km into deep sea.

The solid waste generated by the operation staff is estimated to be about 0.5 kg/day as biodegradable waste and 1 kg/day as non-biodegradable waste.

2.9.4. Management of Air Quality

For preventing dust emissions from the increased movement of vehicles into the harbour, it is proposed to redevelop the access road, provide adequate internal roads and parking areas at the harbour.

2.9.5. Management of Noise Levels and Vibrations

Adequate parking facilities are proposed at the project site to avoid on-road parking, which otherwise would have resulted in increased honking at the site premises.

2.10 Assessment of New & Untested Technology

The layout for constructing open sea fishery harbour and river training work was derived by CWPRS, Pune using latest site-specific data. Following studies were carried out by CWPRS to ensure the efficiency and suitability of the proposed layout to overcome the existing challenges faced by the fishers:

- Littoral drift distribution estimated using LITDRIFT model and modeling was done for shoreline evolution studies.
- The 2-dimensional hydrodynamic model MIKE-21 HD, using flexible mesh used for simulating the flow field.
- Sediment transport studies using MIKE-21 MT in existing and the proposed scenario under prevailing tidal and wave conditions.
- Desk and wave flume studies for the design of breakwater.

2.11 Proposed Schedule for Approval and Implementation

The construction of proposed fishing harbour will commence after obtaining CRZ clearance from SEIAA, Kerala and other statutory approvals/ NOCs required. A period of 48 months is estimated for these construction activities.

2.12 Project Cost

The estimated project cost for the development of the proposed fishing harbour is INR 20,000 Lakhs. The project will be funded in accordance with the Pradhan Mantri Matsya Sampada Yojana (PMMSY) and the funding will be shared by the Central and the State government in the ratio 60:40.

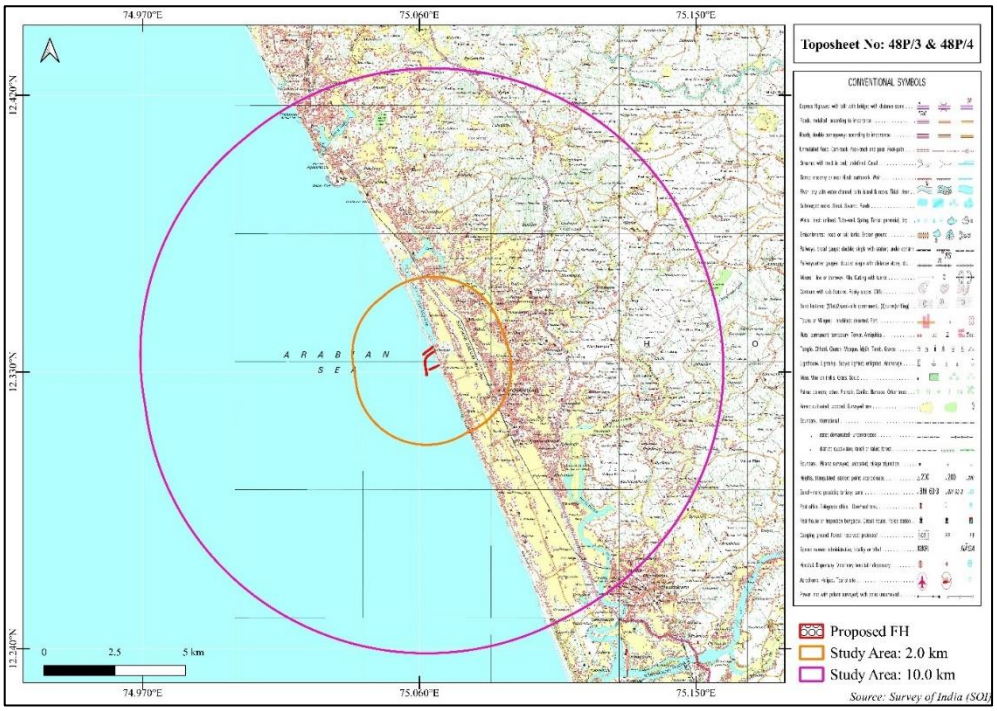
Chapter 3 Description of the Environment

The study area for conducting the EIA studies for the collection of primary baseline data & secondary data for environmental sensitivity is the area surrounding 10.0 km of the project site. Classification of the study area is given in Table 3.1.

Table 3.1: Classification of Study Area

S No.	Study area	Type of Baseline data collection	Attributes
1.	Area within 2.0 km from project site	Primary	Ambient air, noise levels, marine water, marine sediments, surface water, soil, details of flora & fauna
2.	Area outside 2.0 km of the project boundary up to 10.0 km surrounding the project site	Primary & Secondary data from various reliable sources	Ambient air, noise levels, marine water, marine sediments, surface water, soil, Meteorological data, surface water bodies, Flora, Fauna, Socio economic aspects, land use/ land cover (LULC)

The study areas are marked in the Toposheet is given in Figure 3.1.



Source: Survey of India

Figure 3.1: Toposheet of 10 km Study Area

The study area falls in Survey of India (SOI) Topographical Sheets (1:50,000 scale) OSM No. 48P/3, and 48P/4. As per toposheet the project site is located near water body with native vegetation with scattered built-up areas.

3.1 Study Period

Baseline study for the project was conducted for assessing existing environmental status of the area. Primary data and secondary data are collected from 10.0 km study area during study period i.e., from 19.12.2022 to 14.03.2023.

3.1.1 Generation of Baseline Data

Baseline information with respect to air quality, noise level, water quality, soil quality, sediment quality, biological environment and socio-economic environment in the study area were collected through primary sampling and field studies during the study period. The baseline environmental monitoring reports are attached as Annexure 1 of this EIA report.

3.2 Reconnaissance Survey and Ground Truth verification

Reconnaissance survey has been conducted by the EIA consultant for ground truth verification. The photograph of the reconnaissance survey is shown in Figure 3.2.

The field observations are used to:

- Observe the baseline environmental status of study area.
- Identify extent of negative impacts on community/ natural resources.
- Identify mitigation measures and monitoring requirements.



Figure 3.2: Photograph of Reconnaissance Survey Team

3.3 Valued Environmental Components (VEC)

The Valued Environmental Components is shown in Figure 3.3.

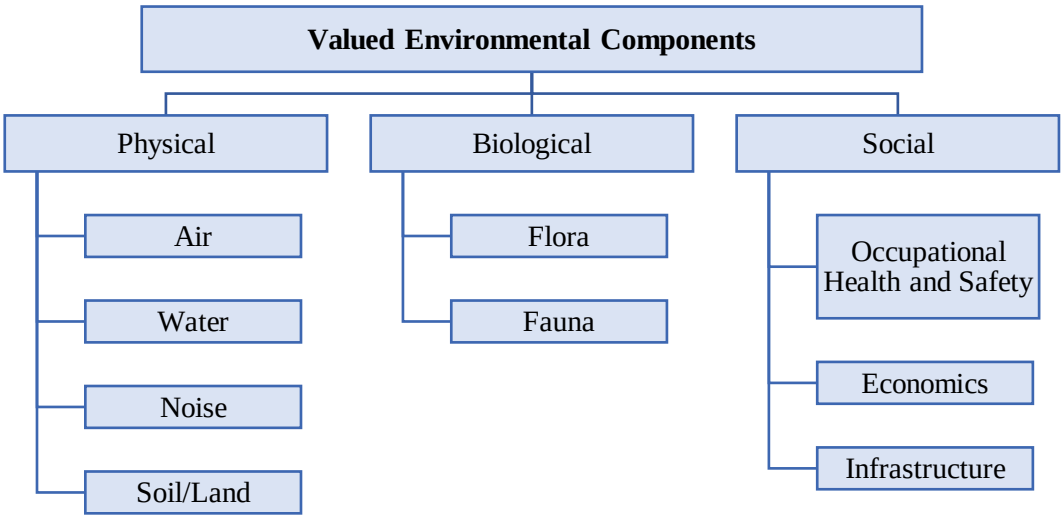


Figure 3.3: VEC

3.4 Sampling Plan

The sampling locations for the baseline monitoring of environmental attributes were identified based on the observations from reconnaissance survey and the following:

- Predominant wind directions in the study area
- Existing topography, drainage pattern and locations of water bodies
- Location of villages/towns/sensitive areas

The sampling plan finalized for environmental baseline monitoring is depicted in Table 3.2.

Table 3.2: Sampling Plan for Environmental Baseline Monitoring

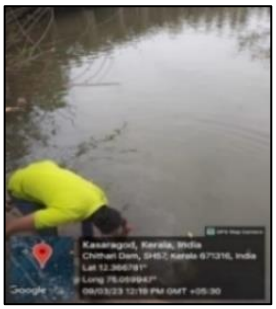
S No	Attribute	Parameters	Frequency of monitoring	No. of locations
1.	Ambient Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NO_2 & CO	24 hourly continuous monitoring (Twice in a week for 12 weeks)	3
2.	Ambient Noise Quality	Leq, Lday, Lnight	Day - 6 AM to 10 PM & Night -10 PM to 6AM (24 hourly continuous monitoring, once during the study period)	3
3.	Surface Water Quality	pH, Colour, Odour, Turbidity, Total Hardness, Iron, Chloride, Fluoride, Total Dissolved Solids, Sulphate, Total Alkalinity, Nitrate, *E.coli*, Total coliform bacteria, Phytoplankton, Zooplankton	Once during the study period	1
4.	Soil	pH, Conductivity, Water Holding Capacity, Organic Matter, Sulphur, Total Phosphorus, Sodium, Potassium, Particle Size distribution, Chloride, Total Kjeldhal Nitrogen, Phosphate.		1
5.	Marine Water Quality	pH, Colour, Odour, Turbidity, Total Hardness, Iron, Chloride, Fluoride, Total Dissolved Solids, Sulphate, Total Alkalinity, Nitrate, Conductivity Calcium, Magnesium, Sodium, Potassium, Mercury, Lead, Copper, Zinc, Cadmium, Total Suspended Solids, Biochemical Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen, Oil & Grease, Salinity,		2

S No	Attribute	Parameters	Frequency of monitoring	No. of locations
		Temperature, Phosphate, *E.coli*, Faecal coliforms, Phytoplankton, Zooplankton		
6.	Marine Sediments	pH, Texture – Sand, Silt & Clay, Organic Matter, Total Phosphorus, Aluminium, Iron, Lead, Manganese, Zinc, Copper, Mercury, Cadmium, Total Kjeldhal Nitrogen, Benthos		2
7.	Meteorology	Wind speed, Wind direction, Temperature, Rainfall, Humidity	NASA POWER Data	

The samples for the primary data generation were analyzed by NABL accredited laboratory engaged by ULTRA TECH. Environmental baseline monitoring photographs are depicted in Figure 3.4.



Noise Level



Surface Water

Figure 3.4: Baseline Monitoring Photographs

3.5 Land Environment

The status of land environment has been assessed through reconnaissance survey at the project site, characterization of soil through field studies and monitoring and through the study of Land Use Land Cover (LULC) using geo-processing software.

3.5.1 Land Use Land Cover

The LULC of the study area i.e., covering aerial distance of 2.0 km and 10.0 km has been prepared using geo-processing software QGIS supported with ground truth verification. Area and distance calculations have been carried out using the software after geo-referencing the interpreted data with the help of the topographical maps and Google Earth Imagery. Details of the data used for LULC is given in Table 3.3.

Table 3.3: Details of satellite image data used for land use classification

Spacecraft Platform & Agency	:	Landsat 08 of NASA and the U.S. Geological Survey (USGS)
Satellite Sensor	:	Multi-spectral Instrument
Sensor ID	:	OLI_TIRS
Entity ID	:	LC08_L2SP_145052_20230227_20230301_02_T1
Acquisition date	:	27.02.2023

Processing Level	:	L2SP
Spatial Resolution	:	30 m

Source: USGS Earth Explorer

Standard False Colour Composite (FCC) Map of satellite image and LULC map of 2 km area of the project is given in Figure 3.5 and Figure 3.6 respectively.

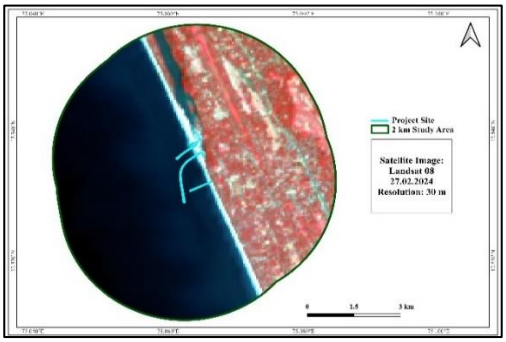


Figure 3.5: Standard FCC Map of Satellite data of 2 km Area

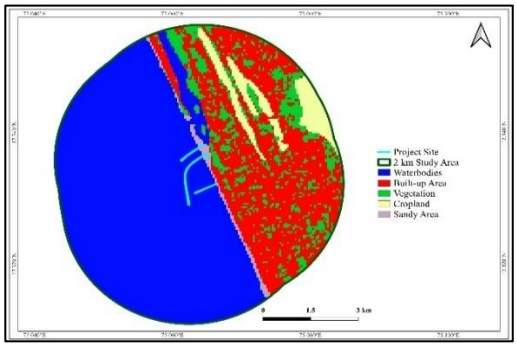


Figure 3.6: LULC of 2 km Area

The statistics of LULC obtained are given in Table 3.4.

Table 3.4: Land use/ Land cover Statistics of Area within 2 km Radius

LULC Classes	Area (in ha)	Area (in %)
Waterbodies	1,019.6	57.17
Built-up area	474.6	26.61
Vegetation	179.5	10.06
Cropland	87.2	4.89
Sandy Area	22.7	1.27
Total	***1,783.53***	***100.00***

Waterbody is prominent in 2 km study area occupying more than half of the land cover, which is further followed by built-up area and vegetation. Cropland is visible in the study area.

Standard False Colour Composite (FCC) Map of satellite image and LULC map of 10 km study area of the project is given in Figure 3.7 and Figure 3.8 respectively.

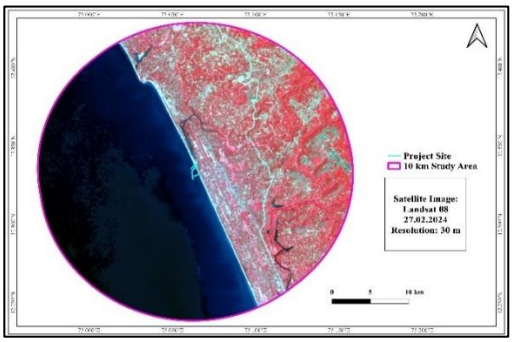


Figure 3.7 : Standard FCC Map of Satellite data of 10 km Study Area

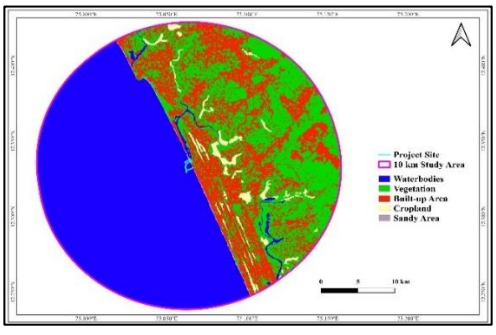


Figure 3.8: LULC of 10 km Study Area

The statistics of LULC obtained are given in Table 3.5.

Table 3.5: Land use/ Land cover Statistics of Area within 10 km Radius

LULC Classes	Area (in ha)	Area (in %)
Waterbodies	17,218.8	50.73%
Vegetation	9,034.0	26.62%
Built-up Area	6,886.5	20.29%
Cropland	694.5	2.05%
Sandy Area	107.6	0.32%
Total	**33,941.52**	**100.00%**

Similar to the LULC map for 2 km study area, more than half of the 10 km study area comprises of waterbodies, with the sea as prominent feature followed by inland water bodies. Vegetation is prominent followed by Built-up area. Cropland consist of paddy fields and other agricultural land which is prominent when compared to sandy area which is on the coastal strip of the sea.

3.5.2 Topography

The elevation of 10 km study area was prepared using Digital Elevation Model (DEM), which is a digital tool or a 3D representation of terrain's surface. The map showing DEM and topographic contour (20.0 m interval) of 2 km study area is shown in Figure 3.9 and that of 10 km study area is show in Figure 3.10. Highest elevation is 185 m AMSL and lowest elevation is -7 m AMSL for 10 km area.

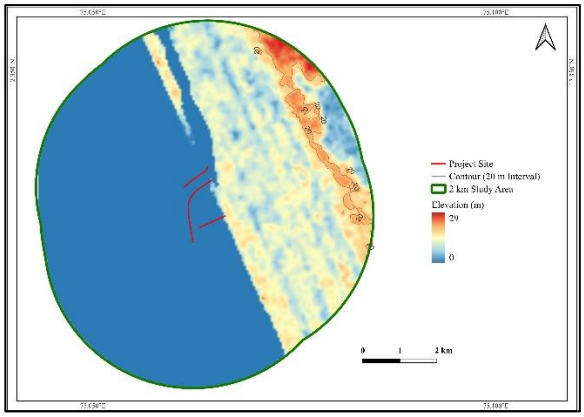


Figure 3.9: DEM of 2 km Area

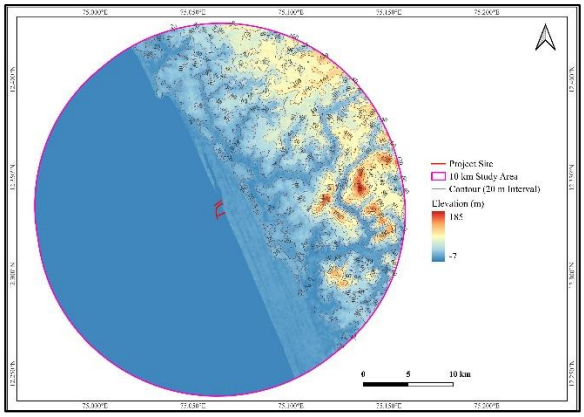


Figure 3.10: DEM of 2 km Area

A slope map provides the colorized representation of slope of an area in degrees. The map showing the slope of 2 km and 10 km study area is shown in Figure 3.11 and Figure 3.12 respectively.

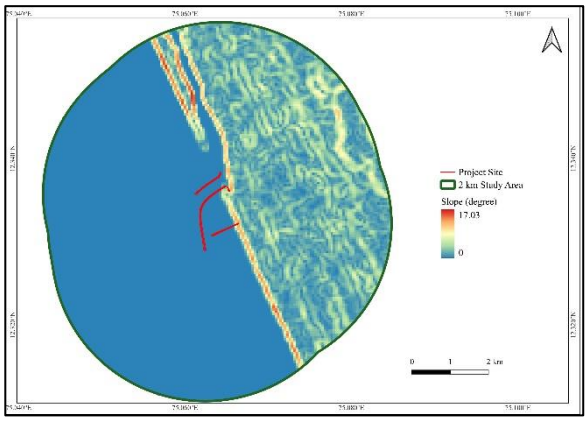


Figure 3.11: Slope Map of 2 km Area

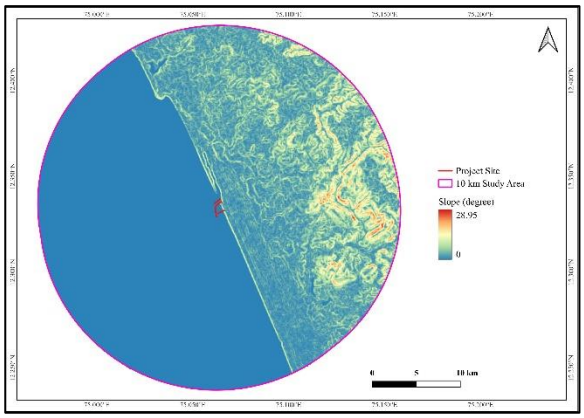


Figure 3.12: Slope Map of 10 km Area

The slope ranged from 0 to 29° in 10 km study area. The aspect map which represents the direction of slope in 2 km study area and 10 km study area is shown in Figure 3.13 and Figure 3.14 respectively.

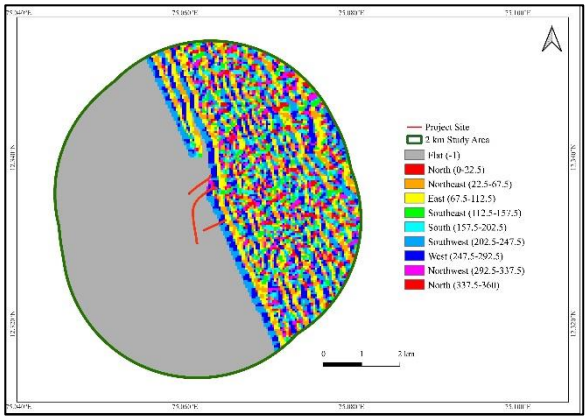


Figure 3.13: Aspect Map of 2 km Area

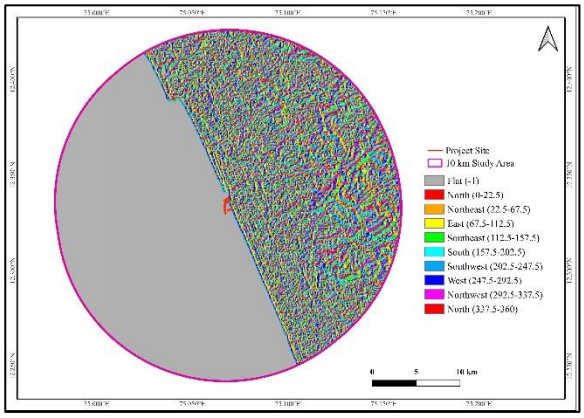


Figure 3.14: Aspect Map of 10 km Area

3.5.3 Soil Quality

Soil is the most important medium for supporting agricultural development. Its properties influence fertility, water retention capacity, physical support capacity of plant roots, and determination of various other chemical constituent parameters. It is thus a vital necessity to study the nutrient status of soil regime.

Methodology for Soil Sampling

- Materials required

Materials required for soil sampling includes spade or auger (screw or tube or post hole type), Khurpi trowel, sampling bags and plastic tray/ bucket.

- Procedure:
  - Divide the field into different homogenous units based on the visual observation.
  - Remove the surface litter at the sampling spot & plough a depth of 5 cm for taking sample.
  - Drive the auger to a plough depth of 15 cm and draw the soil sample.
  - Collect at least 8 to 9 samples from each sampling unit and place in a bucket or tray.

- If auger is not available, make "V" shaped cut to a depth of 15 cm in sampling spot using spade.
- Remove thick slices of soil from top to bottom of exposed face of the "V" shaped cut and place in a clean container.
- Mix samples thoroughly and remove foreign materials like roots, stones, pebbles and gravels.
- Reduce the bulk to about half to 1 kg by quartering or compartmentalization.
- Quartering is done by dividing the thoroughly mixed sample into four equal parts. The two opposite quarters are discarded and the remaining two quarters are remixed and the process repeated until the desired sample size is obtained.
- Compartmentalization is done by uniformly spreading the soil over a clean hard surface and dividing into smaller compartments by drawing lines along and across the length and breadth. From each compartment a pinch of soil is collected. This process is repeated till the desired quantity of sample is obtained.
- Collect the sample in a clean cloth or polythene bag. (Details are given in UT /LQMS/SOP/S00)
- Label the bag with information like location of sampling along with date and time of sampling and name of the sampler etc.

Soil Sampling Locations

Soil conditions near the project site were analysed for their physical & chemical characteristic. Approximately 1 kg of soil sample was collected from the selected location to determine the physico-chemical parameters. Representative soil samples were taken from a depth of 0-15 cm to estimate the soil quality. Soil sample was collected from the project site during the month of March 2023, and the details of sampling location is given in Table 3.6.

Table 3.6: Soil Quality Monitoring Location

S. No.	Location Code	Location Name/ Landmark	Distance (km)	Direction	Selection Criteria	Latitude & Longitude
1.	SQ1	On proposed FLC	-	-	Source of pollution (Non-Agricultural Land)	12°20' 10.06" N 75°3'54.92" E

The soil sampling locations are shown in Figure 3.15.

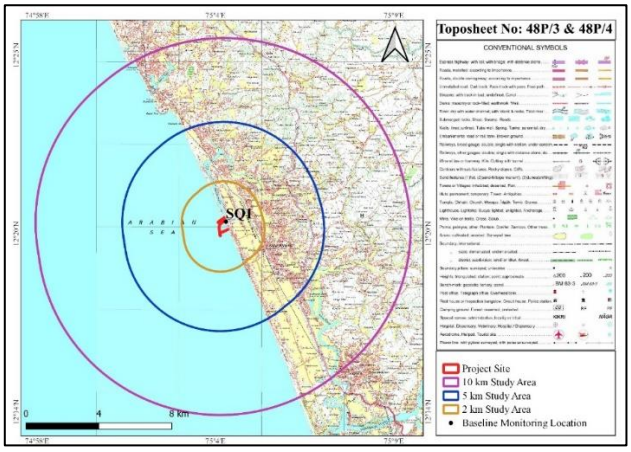


Figure 3.15: Soil Quality Monitoring Location

Results and Observations

The results of the quality analysis performed of at the identified location are given in Table 3.7.

Table 3.7: Soil Quality Analysis Results

S. No	Parameter	Unit	Result of Analysis
1.	pH	--	6.6
2.	Conductivity	µS/cm	282
3.	Water Holding Capacity	%	52
4.	Organic Matter	%	0.23
5.	Sulphur	mg/kg	207.75
6.	Total Phosphorus	mg/kg	23.35
7.	Sodium	mg/kg	159.72
8.	Potassium	mg/kg	208.54
9.	Particle Size distribution (Dry weight basis) a) Above 2.36 mm b) 2.36-1.18 mm c) 1.18 mm-600 microns d) 600-425 microns e) 425-300 microns f) 300-150 microns g) 150-75 microns h) Below 75 microns	%	 12.34 13.28 14.03 11.53 18.20 19.48 6.22 4.92
10.	Chloride (Water extractable)	mg/kg	242.18
11.	Total Kjeldhal Nitrogen	%	771.57
12.	Phosphate	mg/kg	55.60

The standard soil classification is given in Table 3.8.

Table 3.8: Standard Soil Classification

S. No.	Soil test	Classification-Fertility Status
1.	pH	< 4.4 Extremely acidic 4.41- 5.00 very strongly acidic 5.01-6.00 moderately acidic 6.11- 6.40 slightly acidic 6.31-7.30 Neutral 7.21- 7.70 moderately alkaline 8.31-9.0 strongly alkaline > 9.01 very strongly
2.	Salinity Electrical Conductivity µS/cm 1ppm = 640 µS/cm	Up to 1.00 Average 1.1– 1.98 harmful to germination 2.01-3.00 harmful to crops (sensitive to salts)

S. No.	Soil test	Classification-Fertility Status
3.	Organic Carbon (%)	<0.5 Poor Soil 0.5-0.75 Medium Fertile Soil >0.75 Fertile Soil
4.	Phosphorus (kg/ha)	<10 Poor Soil 10-25 Medium Fertile Soil >57 Fertile Soil
5.	Potassium (kg/ha)	<108 - Poor Soil 108-280 -Medium Fertile Soil >280 -Fertile Soil

Source: Soil Survey Manual by IARI (Indian Agricultural Research Institute)

Analysis of Soil Quality Results:

The collected soil samples were analysed for various parameters. pH is an important parameter indicating alkaline and acidic nature of soil. It severally affects the microbial population as well as the solubility of metal ions that regulates nutrient availability. The pH of the soil in the study area is close to neutral. The soluble salts were determined from soil extract (1:2). The soluble salts are expressed in terms of electrical conductivity. The Electrical Conductivity of the soil extract in the study area is 282 µS/cm.

Organic matter present in the soil influences its physical and chemical properties. It commonly accounts as one third or more of the cation exchange capacity of surface soil and is also responsible for stability of soil aggregates. Analysis shows that the concentration of organic matter is 0.23 %. It was observed that fertility of the soil sample is poor in terms of organic matter.

Interpretation

The soil in the study area is characterized as sparsely acidic pH. However, the organic matter content is low, suggesting a need for organic amendments to improve soil fertility and water-holding capacity. The electrical conductivity indicates a high level of salinity.

3.6 Water Environment

3.6.1 Hydrogeology

Groundwater is present in the fractured crystalline aquifer under semi-confined to restricted conditions.

3.6.2 Drainage

The area features network of sea, rivers, canals and lakes, with dendritic drainage pattern. Arabian sea, Chithari River etc. are part of the project area. Drainage map of 2 km study area is shown in Figure 3.16 and drainage map of 10 km study area is given in Figure 3.17.

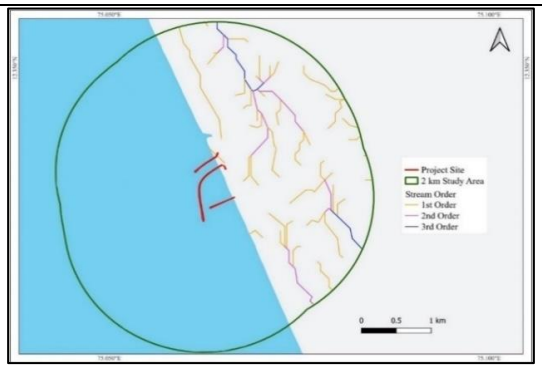


Figure 3.16: Drainage Map of 2 km Area

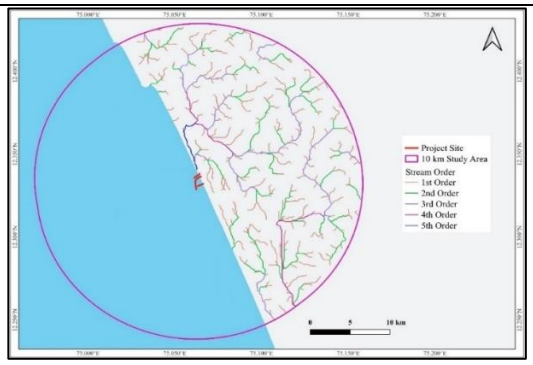


Figure 3.17: Drainage Map of 10 km Study Area

From the drainage maps, it is learned that the study area features dendritic drainage pattern of sea, rivers, canals and lakes.

3.6.3 Surface Water Quality

Sample from was collected from 1 location for surface water quality. Details of the monitoring location are given in Table 3.9.

Table 3.9: Surface Water Monitoring Locations

S. No	Location Code	Location Name /Landmark	Direction	Distance (km)	Selection Criteria	Latitude & Longitude
1.	SW1	Chithari River	NW	3.35 from Northern Breakwater	Chithari River	12°21' 58.5" N 75°3'30.06" E

The surface water quality monitoring locations shown in Figure 3.18.

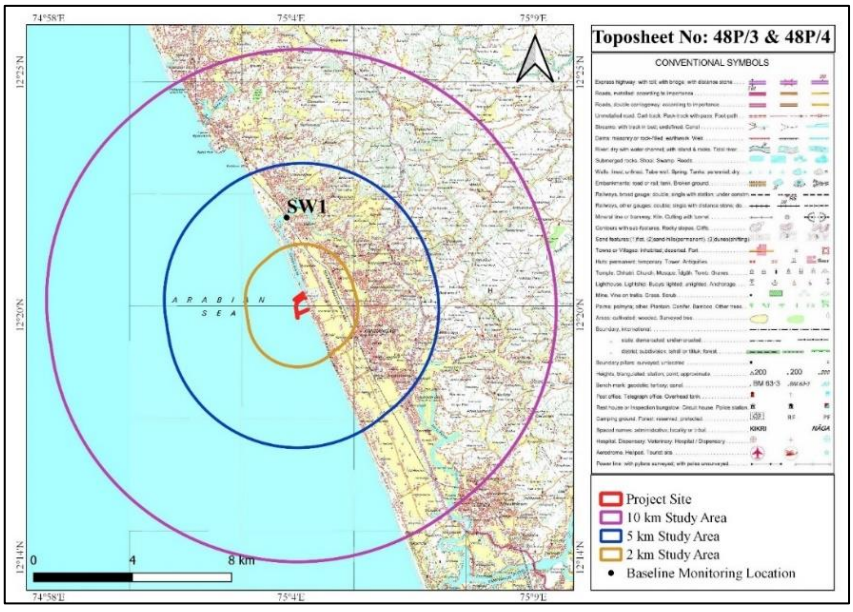


Figure 3.18: Surface Water Monitoring Locations

3.6.3.1. Results and Observations

The results of the surface water quality parameters tested to analyze the characteristics of the water samples are given in Table 3.10.

Table 3.10: Surface Water Quality Analysis Results

S. No	Test Parameter	Unit	Results (SW1)
1.	pH at 25^0C	---	7.5
2.	Colour	Hazen Units	4.0
3.	Odour	---	Agreeable
4.	Turbidity	NTU	0.80
5.	Total Hardness as $CaCO_3$	mg/l	8160
6.	Iron as Fe	mg/l	0.22
7.	Chloride as Cl	mg/l	18345.38
8.	Fluoride as F	mg/l	BDL(MDL-0.2)
9.	Total Dissolved Solids	mg/l	38090
10.	Sulphate as SO_4	mg/l	3324.38
11.	Total Alkalinity as $CaCO_3$	mg/l	133.25
12.	Nitrate as NO_3	mg/l	1.42
13.	*E.coli* or thermotolerant coliform bacteria	MPN/100 ml	<2
14.	Total coliform bacteria	MPN /100 ml	<2
15.	Phytoplankton	cells/ml	40
16.	Zooplankton	cells/ml	20

** BDL: Below Detection Limit*
**MPN: Most Probable Number*
**NTU: Nephelometric Turbidity Unit*

The results show a range of values for various parameters monitored. The pH of surface sample is 7.5, within the typical range for surface water and favourable for aquatic life. The turbidity of 0.80 NTU is relatively low, suggesting clear water with minimal suspended particles. The total hardness of 8,160 mg/L as $CaCO_3$ is high. The chloride concentration of 18,345.38 mg/L and total dissolved solids of 38,090 mg/L is very high, which could make the water salty and unsuitable for drinking. The higher chloride content might be due to the proximity to sea. Sulphate concentration of 3,324.38 mg/L is high, which can contribute to the water's salty taste.

3.6.3.2. Interpretation

The water has a low colour intensity and an agreeable odour, indicating minimal organic pollution. However, Total Dissolved Solids, Total Hardness, Chloride, Sulphate values are slightly higher. The presence of phytoplankton and zooplankton indicates a healthy aquatic ecosystem.

3.6.4 Marine Water and Marine Sediment Quality

Marine water and sediment samples were taken from 2 locations for the analysis of selected parameters. Details of monitoring locations taken for sampling are given in Table 3.11.

Table 3.11: Marine Water & Marine Sediment Quality Monitoring Locations

S. No	Location Code	Location Name	Direction	Distance (km)	Selection Criteria	Latitude & Longitude
1.	MW1 & MS1	Muttumthala Beach	NW	0.25, Northern breakwaters	Source of pollution	12°20'16.65"N 75°3'46.00" E
2.	MW2 & MS2	Proposed breakwater	SW	0.1, Southern Breakwaters	Source of pollution	12°19'53.43" N 75°3'58.21" E

Monitoring locations for sampling is shown in Figure 3.19

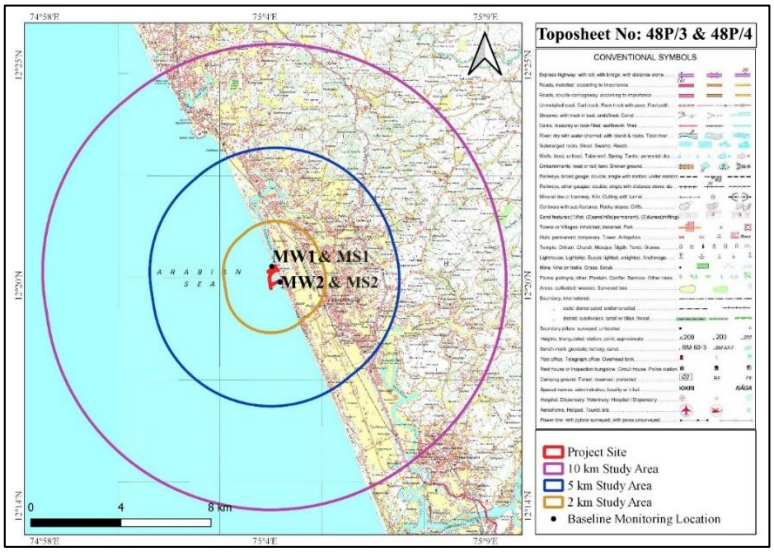


Figure 3.19: Marine water and Sediment Monitoring Locations

3.6.4.1. Results and Observations of the Marine Water Quality

The results of the marine water quality parameters are given in Table 3.12.

Table 3.12: Marine water Quality Analysis Results

S. No	Test Parameter	Unit	Results	
			MW1	MW2
1.	pH at 25^0C	---	7.4	7.4
2.	Colour	Hazen Units	4.0	4.0
3.	Odour	---	Agreeable	Agreeable
4.	Turbidity	NTU	3.80	6.90
5.	Total Hardness as $CaCO_3$	mg/l	7140	8670
6.	Iron as Fe	mg/l	0.46	0.16
7.	Chloride as Cl	mg/l	19568.40	18345.38
8.	Fluoride as F	mg/l	BDL(MDL-0.2)	

9.	Total Dissolved Solids (TDS)	mg/l	38286	37380
10.	Sulphate as SO_4	mg/l	2030.02	2402.50
11.	Total Alkalinity as $CaCO_3$	mg/l	102.50	102.50
12.	Nitrate as NO_3	mg/l	0.34	0.49
13.	Conductivity	µS/cm	63810	62300
14.	Calcium as Ca	mg/l	490.58	613.22
15.	Magnesium as Mg	mg/l	1440.55	1738.59
16.	Sodium as Na	mg/l	10698.14	10012.50
17.	Potassium as K	mg/l	58.62	64.26
18.	Mercury as Hg	mg/l	BDL(MDL-0.0005)	
19.	Lead as Pb	mg/l	BDL(MDL-0.005)	
20.	Copper as Cu	mg/l	BDL(MDL-0.01)	
21.	Zinc as Zn	mg/l	0.08	BDL(MDL-0.01)
22.	Cadmium as Cd	mg/l	BDL(MDL-0.001)	
23.	Total Suspended Solids (TSS)	mg/l	16	22
24.	Biochemical Oxygen Demand (BOD) 27°C for 3 days	mg/l	3.20	3.10
25.	Chemical Oxygen Demand (COD)	mg/l	156	144
26.	Dissolved Oxygen (DO)	mg/l	5.60	5.60
27.	Oil & Grease	mg/l	BDL(MDL-0.05)	
28.	Salinity	mg/l	32264.40	30247.88
29.	Temperature	^0C	31	31
30.	Phosphate as PO4	mg/l	0.49	0.28
31.	E.coli or thermotolerant coliform bacteria	MPN/100ml	<2	<2
32.	Faecal coliforms	MPN /100ml	<2	<2
33.	Phytoplankton	cells/ml	80	160
34.	Zooplankton	cells/ml	40	80

Physical parameters such as colour and odour were within the acceptable limit. pH of the samples indicates a neutral to slightly alkaline condition, suitable for marine ecosystems. The samples showed moderate turbidity, higher at MW2, possibly due to local sediment disturbance. This is within acceptable levels but should be monitored during construction as dredging could increase it significantly. Observed levels of BOD, COD and DO indicate that no immediate oxygen stress is evident and suggest minimal organic pollution and inorganic contaminants. The salinity, TDS, sulphates and chloride levels observed are values consistent with coastal marine environments and are not concerning. Phosphates and Nitrates indicate low nutrient levels and that there is no significant eutrophication risk. Levels of Oil & Grease and Heavy Metals are BDL, except Zn, showing minimal industrial pollution. The trace amount of zinc is not alarming.

3.6.4.2. Interpretation of Marine Water Quality Results

The baseline marine water quality is generally good, with no significant pollution indicators.

3.6.4.3. Results and Observations of Marine Sediment Quality Results

Results of marine sediment quality analysis are given in Table 3.13.

Table 3.13: Marine Sediment Quality Analysis Results

S. No	Test Parameters	Unit	Results	
			MS1	MS2
1.	pH	-	7.2	7.3
2.	Texture - Sand	%	45	41
3.	Texture - Silt	%	7.0	7.0
4.	Texture - Clay	%	48	52
5.	Organic Matter	%	0.03	0.042
6.	Total Phosphorus	mg/kg	58.42	48.49
7.	Aluminium	mg/kg	2.02	1.54
8.	Iron	mg/kg	1007.51	1042.31
9.	Lead	mg/kg	BDL(MDL-1.0)	
10.	Manganese	mg/kg	1.05	1.34
11.	Zinc	mg/kg	2.03	3.29
12.	Copper	mg/kg	1.78	2.57
13.	Mercury	mg/kg	BDL(MDL-0.05)	
14.	Cadmium	mg/kg	BDL(MDL-1.0)	
15.	Total Kjeldhal Nitrogen	%	97.63	101.02
16.	Benthos per sample	-	15	13

pH of the samples is within the limits ranging from 7.2 to 7.3. The samples exhibit a variety of textures, with sand and clay being predominant. Organic matter content is relatively low in all samples. Heavy metals such as lead, mercury and cadmium are in below detectable limits in all samples and iron, manganese, zinc and copper are in moderate level. The abundance of benthic organisms is nearly equal in both the samples.

3.6.4.4. Interpretation of Marine Sediment Quality Results

Sediment sample quality is generally good at sampling locations. Presence of benthic organisms indicating overall health of the marine ecosystem.

3.7 Air Environment

Assessment of baseline air quality has to be undertaken to establish the status of exposure of the major sensitive receptors and to assess the background air quality within the study area. It has to be ensured that the samplers used for the monitoring of air quality have been calibrated by NABL accredited laboratories. The locations for Ambient Air Quality Monitoring have been selected with the guidelines given by MoEF&CC.

3.7.1 Sampling Locations and Methodology

The baseline parameters to be monitored were Particulate Matter (PM_{10}), Particulate Matter ($PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and (CO) at 3 locations. The locations were taken based on wind direction and areas considering environmental and social impacts. The details of monitoring locations are given in Table 3.14.

Table 3.14: Ambient Air Quality Monitoring Locations

S. No	Location Code	Location Name/Landmark	Direction	Distance (km)	Selection Criteria	Latitude & Longitude
1.	AQ1	Near Indian Oil Chithari Fuel	N	2.6, from Northern breakwaters	Cross wind direction	12° 21' 35.56" N 75° 3' 53.20" E
2.	AQ2	Near Iqbal HSS, Kanhangad	E	1.3, from southern breakwaters	Down wind direction	12° 19' 50.37" N 75° 4' 41.77" E
3.	AQ3	Near Fishing harbour, Ajanur	-	0	Source of Pollution	12° 20' 10.03" N 75° 3' 54.57" E

The air quality monitoring locations are shown in Figure 3.20.

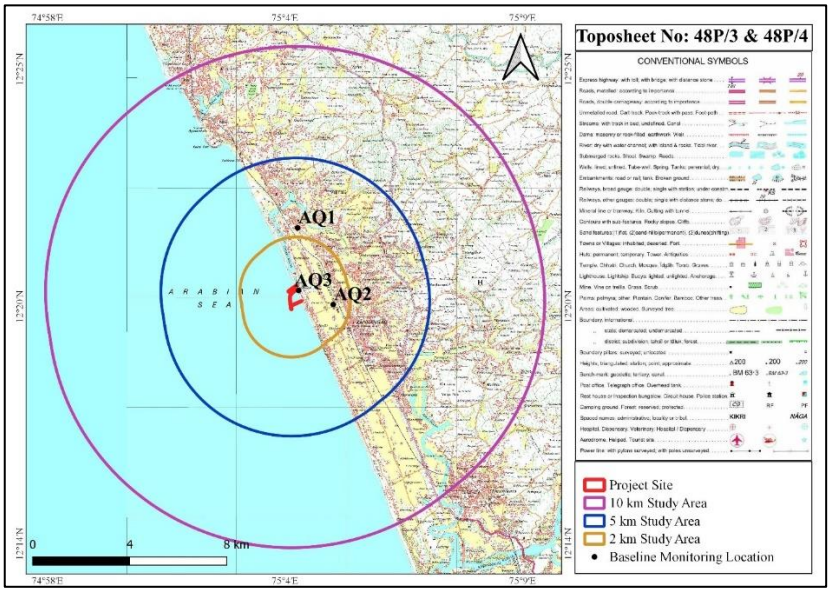


Figure 3.20: Ambient Air Quality Monitoring Locations

3.7.2 Results of Ambient Air Quality Monitoring

The results of the baseline ambient air quality parameters against the permissible ambient air quality standards as per National Ambient Air Quality Standard (NAAQS) issued by Central Pollution Control Board (CPCB) (given in Table 3.18) of the selected location is given in Table 3.15, Table 3.16 and Table 3.17.

Table 3.15: Ambient Air Quality Monitoring Results of PM_{10} and $PM_{2.5}$

Location Code	PM_{10} (µg/m^3)				$PM_{2.5}$ (µg/m^3)			
	Max	Min	Avg.	95th Percentile	Max	Min	Avg.	95th Percentile
AQ1	68.58	66.15	67.36	68.45	22.74	21.01	21.87	22.65
AQ2	63.14	53.81	58.47	62.67	20.39	15.39	17.89	20.14
AQ3	73.57	40.67	57.12	71.92	26.74	9.37	18.05	25.87

Table 3.16: Ambient Air Quality Monitoring Results of SO_2 and NO_2

Location Code	SO_2 (µg/m^3)				NO_2 (µg/m^3)			
	Max	Min	Avg.	95th Percentile	Max	Min	Avg.	95th Percentile
AQ1	13.16	11.15	12.15	13.05	9.88	9.72	9.8	9.87
AQ2	10.17	7.56	8.86	10.03	8.56	4.32	6.44	8.34
AQ3	17.64	3.14	10.39	16.91	13.18	2.06	7.62	12.62

Table 3.17: Ambient Air Quality Monitoring Results of CO

Location Code	CO (mg/m^3)			
	Max	Min	Avg.	95th Percentile
AQ1	0.70	0.65	0.675	0.69
AQ2	0.60	0.6	0.6	0.6
AQ3	1	0.1	0.55	0.95

Table 3.18: NAAQS specified by CPCB and Observed Range of Values at Monitoring Locations

Pollutant	Time Weighted Average	Concentration in Ambient Air as per NAAQS (µg/m^3)	Observed Value Range
PM_{10} (µg/m^3)	24 hours	100	40.67 – 73.57
$PM_{2.5}$ (µg/m^3)	24 hours	60	9.37 – 26.74
SO_2 (µg/m^3)	24 hours	80	3.14 – 17.64
NO_2 (µg/m^3)	24 hours	80	2.06 – 13.18
CO (mg/m^3)	4 hours	2	0.1 - 1

The monitoring results suggests that all the tested parameters PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO are found within the prescribed limits of NAAQS.

Interpretation

This suggests overall air quality is good in the area.

3.7.3 Meteorological Data

Agro-climatological data published in National Aeronautics and Space Administration – Prediction of Worldwide Energy Resources (NASA POWER), based on satellite observations for one year (January

– December 2022) is given in Table 3.19. The data for the year 2022 was used since monthly and annual data are only accessible till 2022 in NASA POWER.

Table 3.19: Monthly Meteorological Data for the Period of One Year (2022)

Month	Temperature (°C)		Relative Humidity (%)	Avg. Wind Speed (m/s)	Dominant Wind Directions	Average Rainfall (mm)
	Max	Min				
January	31.46	21.14	73.19	2.58	NNW	2.16
February	33.15	21.93	68.44	2.7	WNW	1.73
March	35.1	24.23	66.75	2.64	W	34.81
April	34.04	25.37	77.56	2.42	WNW	95.07
May	32.34	24.76	82.94	3.56	WNW	437.35
June	30.07	24.37	84.75	3.09	W	569.94
July	29.27	24.13	90.25	4.16	WNW	1136.19
August	28.14	23.76	90.94	4.14	WNW	952.13
September	28.46	23.6	88.25	3.13	W	359.15
October	29.76	22.57	83.19	2.2	WNW	175.35
November	30.51	21.96	76.81	1.66	SW	60.94
December	31.34	21.32	73.12	2.05	#N/A	72.83

The monthly annual maximum temperature ranges from 28.14 ℃ to 35.1 ℃ and minimum temperature ranges from 21.14℃ to 25.37℃. The temperature is maximum during the month of March and minimum during the month of January. The majority of rainfall is received from south-west monsoon season from July - August. The monthly annual relative humidity ranges between 66.75% and 90.94%. Highest wind speed was found to occur during the months of July. The wind speed ranges from 1.66 m/s to 4.16 m/s with an average of 2.86 m/s. Predominant wind direction is from WNW to ESE.

The meteorological data such as temperature, relative humidity, wind speed, wind direction, solar radiation and precipitation for the baseline monitoring period were taken from NASA POWER. Wind Rose diagram for the proposed project site for the baseline monitoring period is given in Figure 3.21.

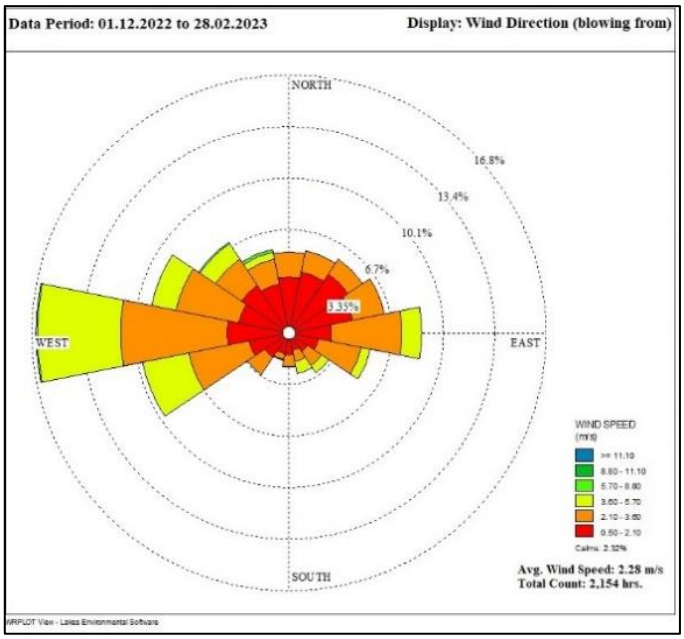


Figure 3.21: Windrose Diagram of Baseline Monitoring Period

The meteorological data of baseline monitoring period meter is given in Table 3.20.

Table 3.20: Meteorological Data of Baseline Monitoring Period

S. No.	Parameter	Minimum	Maximum	Average
1.	Temperature (°C)	25.56	35.58	27.59
2.	Relative Humidity (%)	42.88	92.44	63.47
3.	Wind Speed (m/s)	1.07	4.79	1.89
4.	Solar Radiation (W/m2)	64.26	460.25	110.50
5.	Rainfall	Total rainfall = 16.79mm		
6.	Predominant Wind Direction	W		

3.8 Noise Environment

Baseline noise monitoring is a significant component in evaluating existing conditions of ambient noise in the project site. It further helps to assess whether there is any incremental increase in noise pollution due to the commissioning project.

3.8.1 Sampling Locations and methodology

3 locations were identified for the sampling of ambient noise level in the study area of the project site continuously for 24 hours; 6 AM to 10 PM and 10 PM to 6 AM. The locations have been identified as probable locations where a variation in ambient noise level is expected during construction phase and operation phase. The details of noise level sampling locations are given in Table 3.21.

Table 3.21: Noise Quality Monitoring Locations

S. No.	Location Code	Location Name	Direction	Distance (km)	Justification	Latitude & Longitude
1.	NQ1	Near Indian Oil Chithari Fuel	N	2.6, from Northern breakwaters	Commercial Area	12°21'35.56" N 75°3'53.20" E
2.	NQ2	Near Iqbal HSS, Kanhangad	E	1.3, from southern breakwaters	Silent Zone	12°19'50.37" N 75°4'41.77" E
3.	NQ3	Near Fishing harbour, Ajanur	-	0	Source of pollution	12°20'10.03" N 75°3'54.57" E

Toposheet noise level monitoring locations is given in Figure 3.22.

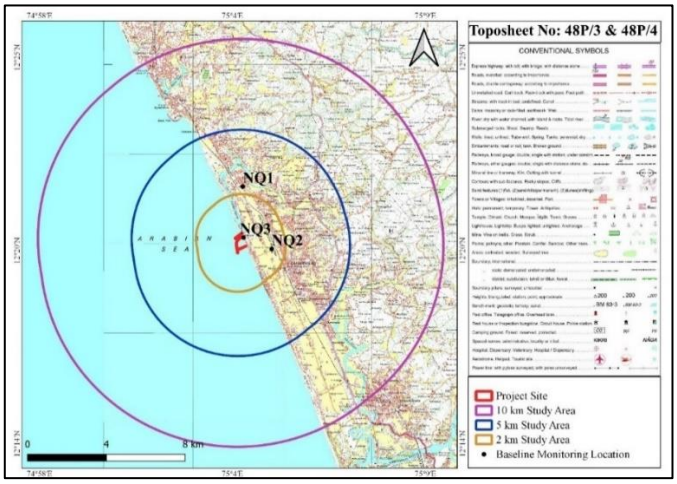


Figure 3.22: Noise Level Monitoring Locations

3.8.2 Permissible Ambient Noise Quality Standards

The Principal Rules of Noise Pollution were published in the Gazette of India, vide S.O. 50 (E) dated 11.01.2010 under the Environment (Protection) Act, 1986. The Noise Level Limits as per Noise Pollution (Regulation and Control) Rules, 2000 and observed baseline ambient noise quality parameters should confirm to the standards specified during the day as well as in the night. Ambient noise level monitoring results are given in Table 3.22.

Table 3.22: Ambient Noise Level Monitoring Results & Noise Level Limits

Location Code	Category	Results in dB (A) Leq		Limit in dB (A) Leq*	
		Day Time (6am – 10pm)	Night Time (10pm – 6am)	Day Time (6am – 10pm)	Night Time (10pm – 6am)
NQ1	Commercial Area	49.8	40.4	**65**	**55**
NQ2	Silence Zone	48.1	37.3	**50**	**40**
NQ3	Commercial Area	42.5	35.6	**65**	**55**

- Commercial Area - Noise quality result of Leq Day and Leq Night time were in the limits of standards prescribed by CPCB for industrial zone as per Noise Pollution (Regulation and Control) Rules, 2000.
- Silence zone - Results were in the limits of standards prescribed by CPCB for silence zone as per Noise Pollution (Regulation and Control) Rules, 2000.

Interpretation

Overall, the results suggest that noise pollution is not a significant concern in the areas around the monitoring locations.

3.9 Biological Environment

Study of biological environment is one of the most important aspects for EIA. Biological communities are the indicators of climatic and edaphic factors, which includes mainly terrestrial ecosystem and aquatic ecosystem.

3.9.1 Objectives of Ecological Study

The study was undertaken with following objectives:

- To evaluate the distribution and composition of vegetation in 10 km study area.
- To assess the distribution of faunal population in 10 km study area.
- To determine the potential ecological impacts of the proposed project on surrounding area and recommendation of mitigation measures, if necessary.
- To identify presence of any species listed under Wildlife (Protection) Amendment Act, 2022 and International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

3.9.2 Sampling Locations

Ecological study was conducted at 4 sampling locations. Toposheet showing sampling locations are given in Figure 3.23.

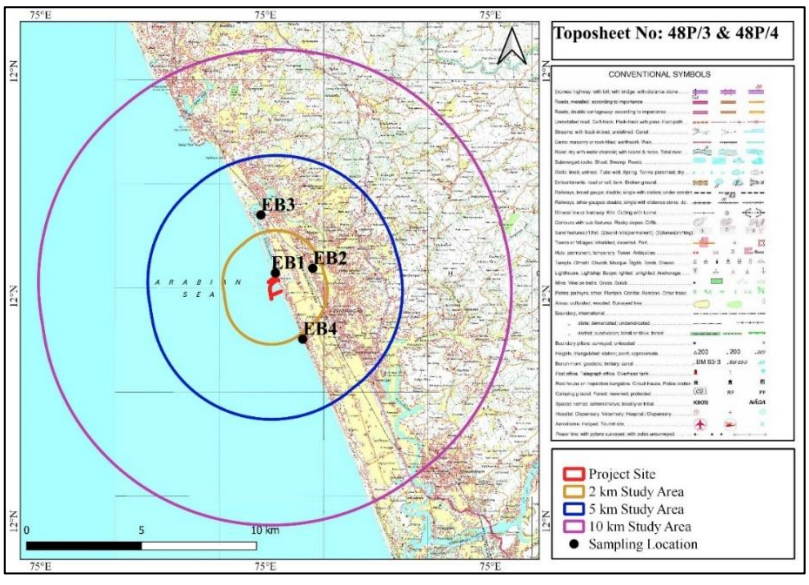


Figure 3.23: Sampling Locations of Ecological Study

3.9.3 Terrestrial Ecology

Terrestrial Flora

Total of 86 floral species are identified from selected locations of 10 km study area, which includes 28 species of trees, 4 species of palms, 18 species of herbs, 16 species of shrubs, 5 species of grass and 15 species of climbers. List of flora observed in the study area is given in Table 3.23.

Table 3.23: List of Flora observed in the Study Area

S. No.	Scientific Name	Local Name / Common Name	Family	Native / Exotic
Trees				
1.	*Acacia auriculiformis**	Acacia	Fabaceae	Exotic
2.	*Albizia lebbeck*	Vaga	Fabaceae	Native
3.	*Alstonia scholaris*	Ezhilamppala	Apocynaceae	Native
4.	*Anacardium occidentale**	Kasumavu	Anacardiaceae	Exotic
5.	*Artocarpus heterophyllus**	Chakka	Moraceae	Native
6.	*Azadirachta indica**	Ariyaveppu	Meliaceae	Native
7.	*Bauhinia purpurea*	Chuvanna Mandaram	Fabaceae	Native
8.	*Butea monosperma*	Plaash	Fabaceae	Native
9.	*Casuarina equisetifolia*	Choolamaram	Casuarinaceae	Exotic
10.	*Ficus benghalensis*	Peraal	Moraceae	Native
11.	*Gliricidia sepium*	Seemakonna	Fabaceae	Exotic
12.	*Leucaena leucocephala*	Black wood	Fabaceae	Exotic
13.	*Macaranga peltate**	Vatta	Euphorbiaceae	Native
14.	*Mangifera indica**	Maavu	Anacardiaceae	Native
15.	*Manilkara zapota*	Chikku	Sapotaceae	Exotic
16.	*Melia azedarach*	Malaveppu	Meliaceae	Native
17.	*Moringa oleifera**	Muringai	Moringaceae	Native
18.	*Muntingia calabura*	Pancharappazham	Muntingiaceae	Exotic
19.	*Phyllanthus emblica*	Nelli	Phyllanthaceae	Native
20.	*Polyalthia longifolia*	Aranamaram	Annonaceae	Native
21.	*Pongamia pinnata*	Pongam	Fabaceae	Native
22.	*Psidium guajava**	Pera	Myrtaceae	Exotic
23.	*Samanea saman*	Mazhamaram	Fabaceae	Exotic
24.	*Syzygium cumini*	Njaval	Myrtaceae	Native
25.	*Tamarindus indica**	Kolpuli	Caesalpiniaceae	Exotic
26.	*Terminalia arjuna*	Nirmarutu	Combretaceae	Native
27.	*Terminalia catappa**	Badam	Combretaceae	Exotic
28.	*Thespesia populnea**	Poovaras	Malvaceae	Native
Palms				
1.	*Areca catechu**	Kavungu	Palmae	Native

S. No.	Scientific Name	Local Name / Common Name	Family	Native / Exotic
2.	*Borassus flabellifer*	Nonku	Arecaceae	Native
3.	*Caryota urens*	Anappana	Arecaceae	Native
4.	*Cocos nucifera**	Thengu	Arecaceae	Native
Herbs				
1.	*Ageratum conyzoides**	Kumminipacha	Asteraceae	Exotic
2.	*Alternanthera sessilis**	Kozhuppacheera	Amaranthaceae	Native
3.	*Boerhavia diffusa**	Thazhuthama	Nyctaginaceae	Native
4.	*Catharanthus roseus*	Shavamnaari	Apocynaceae	Exotic
5.	*Centella asiatica*	Muthil	Apiaceae	Native
6.	*Chromolaena odorata**	Communistpacha	Asteraceae	Exotic
7.	*Cleome viscosa*	Naivela	Capparidaceae	Exotic
8.	*Colocasia esculenta*	Chembu	Araceae	Native
9.	*Dipteracanthus prostrates**	Thuppalampotti	Acanthaceae	Native
10.	*Euphorbia hirta*	Nelapaala	Euphorbiaceae	Exotic
11.	*Fimbristylis cymose**	Vayal Potta	Cyperaceae	Native
12.	*Gomphrena celosioides*	Neervadamalli	Amaranthaceae	Exotic
13.	*Ipomoea pes-caprae**	Kuthirakulamban	Convolvulaceae	Native
14.	*Launaea sarmentosa**	Kadalkozhuppa	Asteraceae	Native
15.	*Mimosa pudica**	Thottavadi	Mimosaceae	Exotic
16.	*Musa paradisiaca**	Vazha	Musaceae	Exotic
17.	*Tridax procumbens**	Sanippoovu	Asteraceae	Exotic
18.	*Wedelia trilobata**	Singapore Daisy	Asteraceae	Exotic
Shrubs				
1.	*Barleria cristata*	Karimkurunni	Acanthaceae	Native
2.	*Bougainvillea spectabilis*	-	Nyctaginaceae	Exotic
3.	*Caesalpinia pulcherrima**	Settimandaram	Fabaceae	Exotic
4.	*Calotropis gigantea**	Erikku	Asclepiadaceae	Native
5.	*Clerodendrum inerme*	Cheruchinna	Verbenaceae	Native
6.	*Helicteres isora*	Edampiri-Valampiri	Sterculiaceae	Native
7.	*Hibiscus rosa-sinensis*	Chemparati	Malvaceae	Exotic
8.	*Hibiscus surattensis*	Kakkapoovu	Malvaceae	Native
9.	*Ixora coccinea**	Thechi	Rubiaceae	Native
10.	*Ixora elongata*	Rose Chetthi	Rubiaceae	Native
11.	*Jatropha curcas*	Katalavanakku	Euphorbiaceae	Exotic
12.	*Lantana camara**	Arippoo	Verbenaceae	Exotic
13.	*Mussaenda frondosa**	Vellila	Rubiaceae	Native
14.	*Phyllanthus reticulatus**	Nirnelli	Phyllanthaceae	Native
15.	*Urena lobata*	Oorpam	Malvaceae	Native

S. No.	Scientific Name	Local Name / Common Name	Family	Native / Exotic
16.	*Vitex trifolia**	Vellanochi	Verbenaceae	Native
Grasses				
1.	*Chloris barbata**	Kodappullu	Poaceae	Exotic
2.	*Cynodon dactylon**	Karukappullu	Poaceae	Native
3.	*Fimbristylis cymosa*	Vayalpotta	Cyperaceae	Exotic
4.	*Paspalum distichum*	Kulavaragu	Poaceae	Native
5.	*Zoysia matrella**	Cherupullu	Poaceae	Native
Climbers				
1.	*Antigonon leptopus*	Thenpoovalli	Polygonaceae	Exotic
2.	*Calopogonium mucunoides**	Wild Ground Nut	Fabaceae	Exotic
3.	*Centrosema mole**	Kattupayar	Fabaceae	Exotic
4.	*Combretum indicum**	Yasodapoo	Combretaceae	Exotic
5.	*Dioscorea bulbifera*	Kattukachil	Dioscoreaceae	Native
6.	*Jasminum multiflorum*	Mulla	Oleaceae	Native
7.	*Mikania micrantha**	Dhridharashtrappacha	Asteraceae	Exotic
8.	*Mimosa diplotricha*	Anathottavadi	Fabaceae	Exotic
9.	*Passiflora foetida*	Poochapazham	Passifloraceae	Exotic
10.	*Piper longum*	Thippali	Piperaceae	Native
11.	*Piper nigrum*	Kurumulaku	Piperaceae	Native
12.	*Pueraria phaseoloides**	Thottapayar	Fabaceae	Exotic
13.	*Quisqualis indica*	Thookuchethi	Combretaceae	Native
14.	*Tinospora cordifolia**	Chittamruthu	Menispermaceae	Native
15.	*Xenostegia tridentata*	Prasarani	Convolvulaceae	Native

Source: Primary data generated by ULTRA TECH Team

**Also observed in the core zone*

Photographs of flora observed in the study area is given in Figure 3.24.



Cocos nucifera



Terminalia catappa



Casuarina equisetifolia



Acacia auriculiformis


Ipomoea pes-caprae


Vitex trifolia


Chromolaena odorata


Launaea sarmentosa

Figure 3.24: Photographs of Flora observed in the Study Area

- *Rare/Endangered/Threatened (RET) Flora*

There is no RET species of flora within the study area as per the IUCN Red List of Threatened Species-2014.

Terrestrial Fauna

Transact method was employed for the identification of birds and butterflies. Mammals were recorded by direct sightings and indirect evidences such as pug marks, scats, droppings etc. The authenticity of faunal occurrence was confirmed by interactions with local people. Total of 7 species of insects, 6 species of odonates, 14 species of butterflies, 6 species of reptiles, 16 species of avifauna and 8 species of mammals were observed in study area. List of fauna observed in study area are given in Table 3.24.

Table 3.24: List of Fauna observed in the Study Area

S. No.	Scientific Name	Family	Common Name	IUCN Status** / WPA Schedule
Insects				
1.	*Abscondita chinensis**	Lampyridae	Firefly Beetle	-
2.	*Anoplolepis gracilipes**	Formicidae	Yellow Crazy Ant	-
3.	*Apis cerana indica*	Apidae	Asian Honey Bee	-
4.	*Camponotus compressus*	Formicidae	Indian Black Ant	-
5.	*Ommatoiulus moreleti**	Julidae	Portuguese Millipede	-
6.	*Omocestus viridulus**	Acrididae	Common Green Grasshopper	-
7.	*Probergrothius sanguinolens*	Pyrrhocoridae	Indian Red Bug	-
Odonates				
1.	*Bradinopyga geminata*	Libellulidae	Granite Ghost	LC
2.	*Diplacodes trivialis**	Libellulidae	Chalky Percher	LC
3.	*Orthetrum sabina**	Libellulidae	Slender Skimmer	LC
4.	*Rhodothemis rufa*	Libellulidae	Common Redbolt	LC
5.	*Trithemis festiva*	Libellulidae	Indigo Dropwing	LC

S. No.	Scientific Name	Family	Common Name	IUCN Status** / WPA Schedule
6.	*Vestalis apicalis*	Calopterygidae	Black Tipped Forest Glory	LC
		Butterflies		
1.	*Acraea terpsicore**	Nymphalidae	Tawny Coster	-
2.	*Castalius rosimon**	Lycaenidae	Common Pierrot	-
3.	*Catopsilia Pomona**	Pieridae	Common Emigrant	-
4.	*Colotis aurora*	Pieridae	Plain Orange-tip	-
5.	*Euploea core**	Nymphalidae	Common Crow	LC
6.	*Eurema hecabe*	Pieridae	Grass Yellow	LC
7.	*Junonia iphita**	Nymphalidae	Chocolate Pansy	-
8.	*Junonia lemonias**	Nymphalidae	Lemon Pansy	-
9.	*Leptosia nina**	Pieridae	Psyche	-
10.	*Melanitis leda*	Nymphalidae	Twilight Brown	LC
11.	*Mycalesis mineus*	Nymphalidae	Branded Bushbrown	-
12.	*Neptis hylas**	Nymphalidae	Common Sailor	-
13.	*Papilio polytes*	Papilionidae	Common Mormon	-
14.	*Tirumala limniace**	Nymphalidae	Blue Tiger	-
		Reptiles		
1.	*Calotes versicolor**	Agamidae	Garden Lizard	LC
2.	*Eutropis carinata**	Scincidae	Keeled Indian Mabuya	LC
3.	*Hemidactylus flaviviridis**	Gekkonidae	Yellow Bellied House Gecko	LC
4.	*Lampropholis guichenoti*	Scincidae	Pale-flecked Garden Sunskink	LC
5.	*Lygosoma punctata*	Scincidae	Common Dotted Garden Skink	LC
6.	*Ptyas mucosa*	Colubridae	Rat Snake	LC, Sch I (Part C)
		Avifauna		
1.	*Alcedo atthis**	Alcedinidae	Common Kingfisher	LC, Sch II (Part B)
2.	Alexandrinus krameri	Psittacidae	Rose-ringed Parakeet	LC, Sch II (Part B)
3.	*Argya striata**	Leiotrichidae	Jungle Babbler	LC, Sch II (Part B)
4.	*Bubulcus Egret*	Ardeidae	Cattle Egret	Sch II (Part B)
5.	*Centropus sinensis*	Cuculidae	Greater Coucal	LC, Sch II (Part B)
6.	*Cinnyris asiaticus*	Nectariniidae	Purple Sunbird	LC, Sch II (Part B)
7.	*Columba livia**	Columbidae	Rock Dove	LC
8.	*Corvus splendens**	Corvidae	House Crow	LC
9.	*Dicrurus macrocercus**	Dicruridae	Black Drongo	LC, Sch II (Part B)
10.	*Egretta garzetta**	Ardeidae	Little Egret	LC, Sch II (Part B)

S. No.	Scientific Name	Family	Common Name	IUCN Status** / WPA Schedule
11.	*Eudynamys scolopaceus*	Cuculidae	Asian Koel	LC, Sch II (Part B)
12.	*Haliastur indus*	Accipitridae	Brahminy Kite	LC, Sch I (Part B)
13.	*Microcarbo niger**	Phalacrocoracidae	Little Cormorant	LC, Sch II (Part B)
14.	*Milvus migrans*	Accipitridae	Black Kite	LC, Sch II (Part B)
15.	*Orthotomus sutorius*	Cisticolidae	Common Tailorbird	LC, Sch II (Part B)
16.	Yungipicus nanus	Picidae	Brown-capped Pygmy Woodpecker	LC, Sch II (Part B)
Mammals				
1.	*Bandicota indica**	Muridae	Greater Bandicoot Rat	LC
2.	*Bos taurus**	Bovidae	Cow	-
3.	*Canis lupus familiaris**	Canidae	Indian Native Dog	-
4.	*Capra aegagrus hircus*	Bovidae	Goat	-
5.	*Felis catus**	Felidae	Domestic Cat	-
6.	*Funambulus palmarum**	Sciuridae	Indian palm squirrel	LC
7.	*Mus musculus*	Muridae	House Mouse	LC
8.	*Sus scrofa*	Suidae	Wild Boar	LC, Sch II (Part A)

Source: Primary data generated by ULTRA TECH Team

**Also observed in the core zone*

***LC - Least Concern*

- *Rare/Endangered/Threatened (RET) Fauna*

No threatened, endangered & endemic species and migratory fauna were observed in the study area as per International Union for Conservation of Nature (IUCN) Red List of Threatened Species. *Ptyas mucosa* (Rat Snake), *Haliastur indus* (Brahminy Kite), Schedule I species as per Wildlife (Protection) Amendment Act, 2022 were found in the study area.

National Parks and Wildlife Sanctuaries

There is no National Parks and Wildlife Sanctuaries present within 10 km study area.

3.9.4 Aquatic Ecology

List of aquatic organisms observed in the study area is given in Table 3.25.

Table 3.25: List of Aquatic Organisms observed in the Study Area

S. No.	Scientific Name	Family	Common Name	IUCN Status**/ WPA Schedule
Arthropods				
1.	*Metapenaeus monoceros*	Penaeidae	Speckled Shrimp	-
2.	*Ocypode ceratophthalmus**	Ocypodidae	Horn-eyed Ghost Crab	-

S. No.	Scientific Name	Family	Common Name	IUCN Status**/ WPA Schedule
3.	*Penaeus indicus*	Penaeidae	Indian Prawn	-
4.	*Penaeus monodon*	Penaeidae	Giant Tiger Prawn	-
5.	*Tachypleus gigas*	Limulidae	Horseshoe Crab	DD, Sch II (Part G)
Molluscs				
1.	*Meretrix casta*	Veneridae	Backwater Hard Clam	-
2.	*Perna indica**	Mytilidae	Brown Mussel	-
3.	*Perna viridis*	Mytilidae	Asian Green Mussel	-
4.	*Portunus sanguinolentus*	Portunidae	Three Spot Swimming Crab	-
5.	*Sepia spp.**	Sepiidae	Cuttlefish	-
Fishes				
1.	*Auxis thazard thazard*	Scombridae	Frigate tuna	-
2.	*Diodon hystrix*	Diodontidae	Spot fin Porcupinefish	LC
3.	*Lactarius lactarius*	Lactariidae	False Trevally	-
4.	*Mugil cephalus*	Mugilidae	Flathead Mulle	LC
5.	*Nemipterus japonicus*	Nemipteridae	Pink Perch	LC
6.	*Pampus argenteus*	Stromateidae	Silver Pomfret	-
7.	*Parastromateus niger*	Carangidae	Black Pomfret	LC
8.	*Plicofollis dussumier*	Ariidae	Blacktip sea catfish	LC
9.	*Rastrelliger kanagurta*	Scombridae	Mackerel	DD
10.	*Sardinella gibbosa*	Clupeidae	Goldstripe sardinella	LC
11.	*Sardinella longiceps*	Clupeidae	Indian Oil Sardine	LC
12.	*Stolephorus indicus*	Engraulidae	Indian Anchovy	LC
Echinodermates				
1.	*Asterias spp.**	Asteriidae	Star Fish	-

Source: Primary data generated by ULTRA TECH Team

**Also observed in the core zone*

***LC - Least Concern, DD – Data Deficient*

Photographs of fauna observed in the study area is given in Figure 3.25.



Asterias spp.



Sepia spp. (Cuttlefish Bone)



Ocypode ceratophthalmus

Figure 3.25: Photographs of Fauna observed in the Study Area

3.9.5 Interpretation

The project site possesses medium biodiversity with reference to flora and fauna. Biodiversity will be increased by the development of landscaping in an area of about 3,000 m^2 through the plantation of different varieties of trees considering different environmental and ecological components. Apparently, project activities will not have any adverse impact on flora and fauna in the study area. No threatened, endangered, vulnerable & endemic species of flora and fauna were observed in the study area as per International Union for Conservation of Nature (IUCN) Red List of Threatened Species.

3.10 Socio-Economic Environment

The socio-economic evaluation focuses on the project impact on social and economic well-being of the population within 10.0 km radius of the project site and has been prepared based on secondary data extracted from Primary Census Abstract, Census of India 2011. Demographic data of Ajanur, village, where the project site reside is given in Table 3.26.

Table 3.26: Demographic Attributes of the Study Area

Name of village	No. of households	Total population	Literates	Working Population	Main worker	Marginal worker	Non worker
Ajanur	7,027	33,079	25,791	10,873	9,141	1,732	22,206

Data Source: Census of India, 2011

Out of total population, are 32.86 % are working population. Main workers, marginal workers and non-workers are 27.6 %, 5. 2 % and 67.1 % of total population respectively.

3.10.1 Stakeholder Consultation

Consultation meeting was conducted with Ms. Shobha T. (President of Grama Panchayath), Mr. Ibrahim Mavikaal (ward member of ward 18), Mr. K. Ravindran (ward member of ward 17), Ms Sathi K. (ward member of ward 20), Ms. Meena K. (Chairperson, Development Standing Committee), and Mr. Rajesh P. R. (Assistant Engineer, Harbour Engineering Department) on 14.03.2023 using a structural questionnaire to understand the existing socio-economic conditions, improvement required for the existing social infrastructures, issues and concerns of public regarding proposed harbour etc. were given.

During the consultation, it was learned that:

- The proposed project received widespread support from the community as it was expected to create employment opportunities. A significant portion of the underprivileged fishing community in Kasaragod district resides in Ajanur. The construction of a harbour in this region could potentially improve the livelihoods of the local fishing community and thereby improve their current living conditions.
- Considering the site's historical record of boat accidents, the construction of a harbour is deemed essential to enhance safety and reduce the risk of future incidents.
- The only concern regarding the proposed project is waste disposal.
- While some stakeholders requested improvements, the primary suggestions cantered on increasing the number of rescue boats and personnel.

- Additionally, coastal erosion and sea encroachment in the area necessitated the construction of sea walls, while stakeholders also suggested improvements to the existing fisheries station facilities.

3.10.2 Door-to-Door Survey

Methodology of door-to-survey

10.0 km area around the project site is selected for door-to-door survey. Stratified random sampling was conducted where the area was divided into three zones based on the distance from the proposed project site. The study area was classified viz., up to 2.0 km, 2.0 km to 5.0 km and 5.0 km to 10.0 km from project site for conducting door-to-door survey. A total of 6 responses were recorded during the survey. Photographs of stakeholder consultation and door-to-door survey are given in Figure 3.26.



Figure 3.26: Photographs of Stakeholder Consultation & Door-to-Door Survey

From the door-to-door survey it was observed that, 83% of respondents have a secondary education, and 17% have a primary education. In terms of occupation, 83% are fishermen, and 17% are pensioners.

The economic status of the people was assessed based on their ration cards. The majority of people, approximately 50%, possess a pink card, which indicates that majority of the population belong to below poverty line, while 33% have a yellow card and 17% have a blue card. The proximity of the sea and the issue of saltwater intrusion have forced all residents to depend exclusively on pipeline water for their water needs.

The region faces recurring threats of flooding and sea encroachment. 20% of respondents reported experiencing both a tsunami and a flood, while 60% indicated that they face sea attack.

In the course of the survey, they were asked about the need or improvement in basic amenities such as electricity, drinking water supply, street lights, solid waste management, liquid waste management, educational institution, roads, health sector etc. Among the most pressing needs identified were drinking water (28%), street lights (24%), sea walls (18%), electricity and solid waste management (12%).

The graphical representation of the summary of door-to-door survey is shown in Figure 3.27.

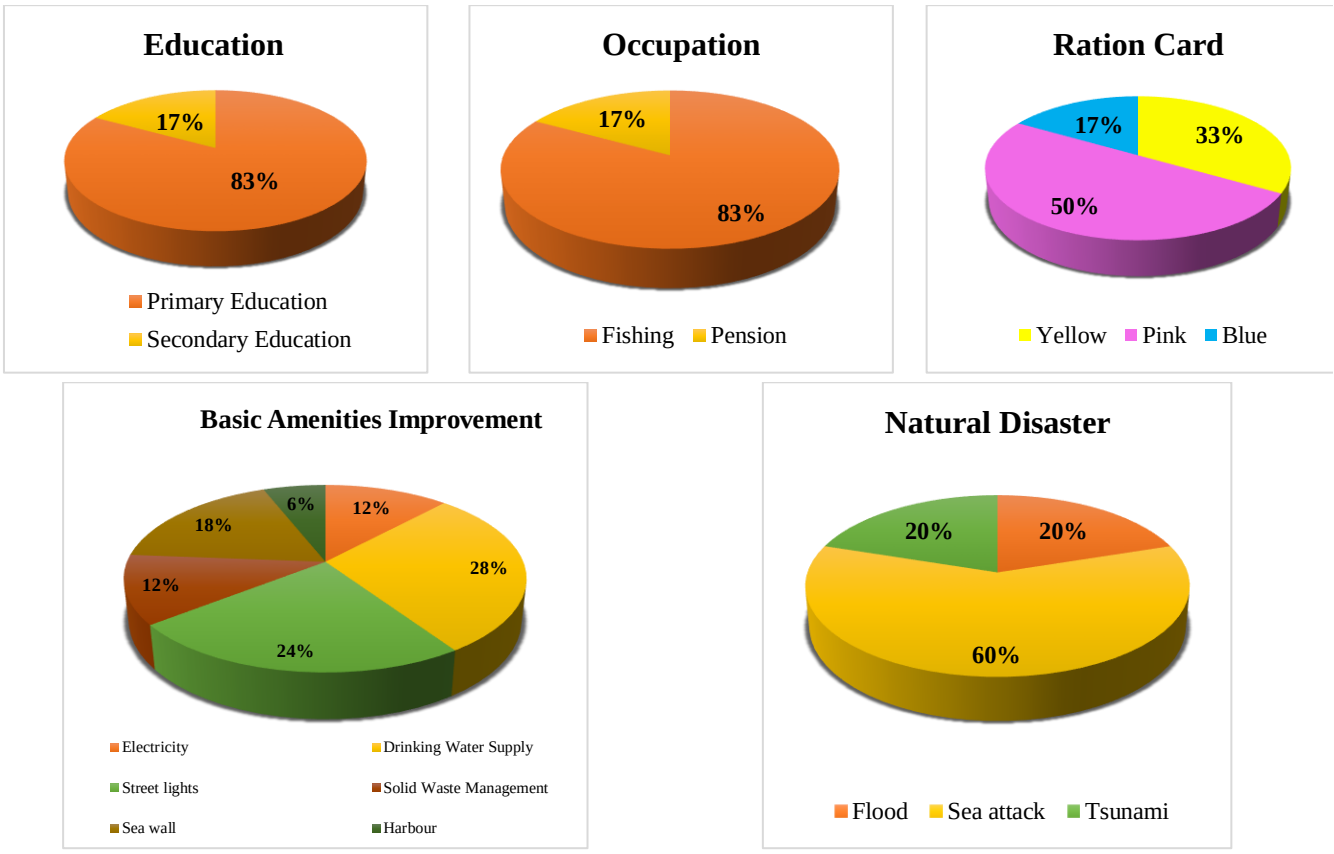


Figure 3.27: Summary of Door-to-Door Survey

3.11 Natural Hazards

3.11.1 Cyclone

As per the Wind Hazard Map prepared by Building Materials and Technology Promotion Council (BMTPC), Ministry of Housing & Urban Affairs (MoH), Government of India (GoI), the project location is coming under Moderate Damage Risk Zone B - Vb: 39 m/s. Wind Hazard given in Figure 3.28. Cyclone Occurrence Map (Coastal India) prepared by BMTPC shows the Maximum Sustained Windspeed (MSW) is 34 - 47 knots for the site. The Cyclone Occurrence Map is given in Figure 3.29.

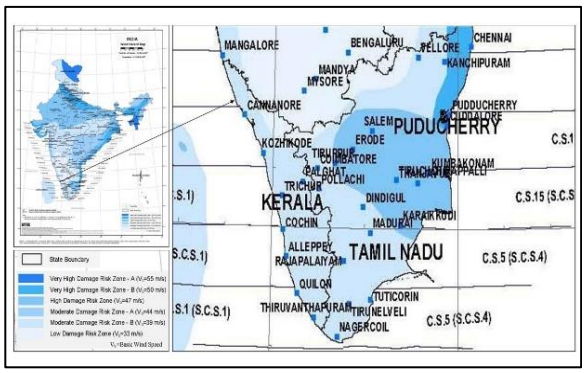


Figure 3.28: Wind Hazard Map

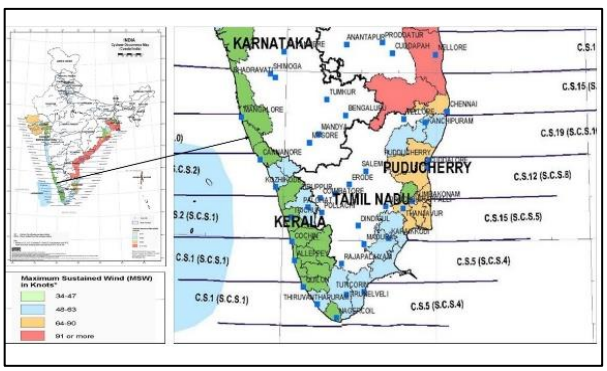


Figure 3.29: Cyclone Occurrence Map

Source: BMTPC

3.11.2 Lightning

As per DDMP Kasaragod 2015, the project site is near to lightning susceptible area and the lightning frequency per year for the project site is 1. However, no history of lightning was reported by the locals during the socioeconomic survey. The Lightning Susceptibility Map and Lightning Frequency Map of Kasaragod district are given in Figure 3.30 and Figure 3.31 respectively.

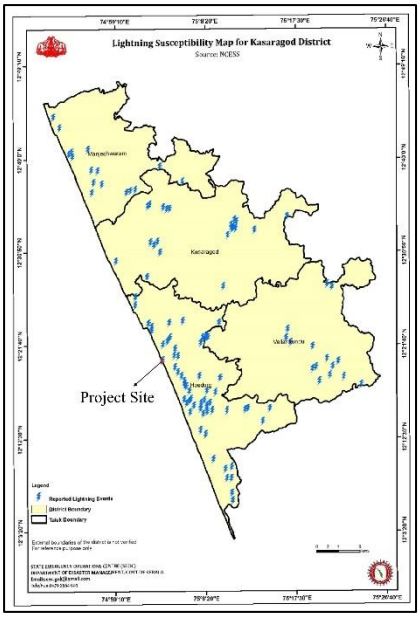


Figure 3.30: Lightning Susceptibility Map

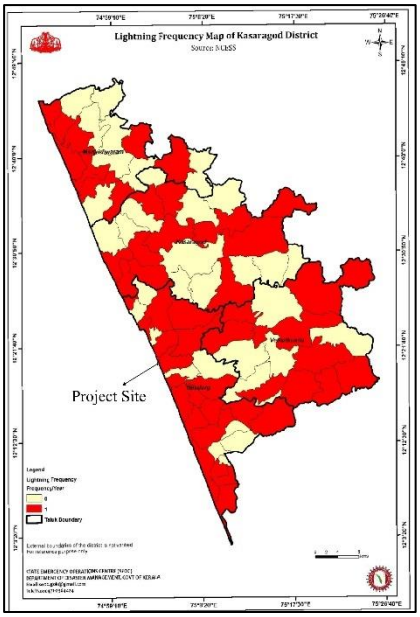


Figure 3.31: Lightning Frequency Map

Source: DDMP 2015, Kasaragod

3.11.3 Earthquake

As per the Seismic Zone classification by IS 1893 (Part-I): 2002 prepared by Geological Survey of India (GSI) the proposed project site is falls under Seismic Zone III (Moderate Risk Zone). The Seismic Zone Map of India is given in Figure 3.32.

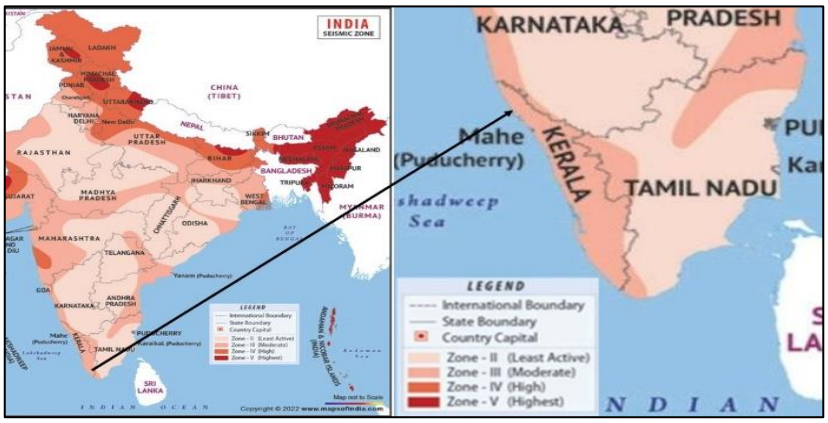
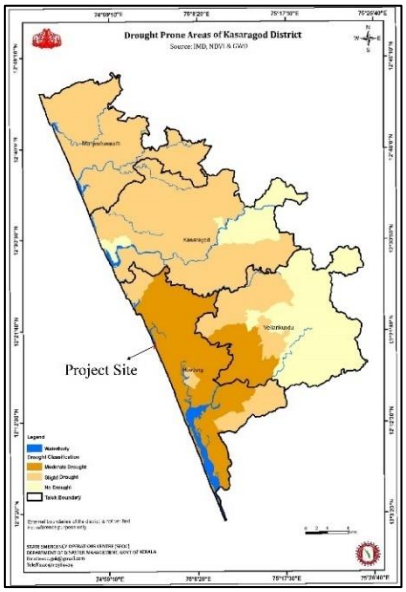


Figure 3.32: Earthquake Susceptibility Map

Source: Geological Survey of India

3.11.4 Drought

As per Drought Prone Area Map of Kasaragod district prepared by NCESS for DDMP 2015 given in Figure 3.33 the project site falls in moderate drought prone area.

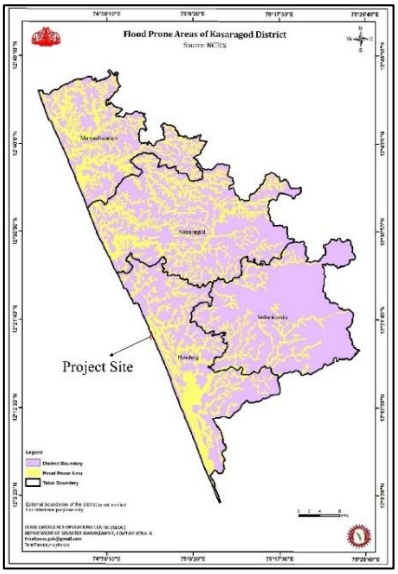


Source: DDMP 2015, Kasaragod

Figure 3.33: Drought Prone Area Map

3.11.5 Flood

As per the flood susceptibility map of Kasaragod district prepared by NCESS for DDMP 2015 given in Figure 3.34 project site is falls under Flood Prone Area.

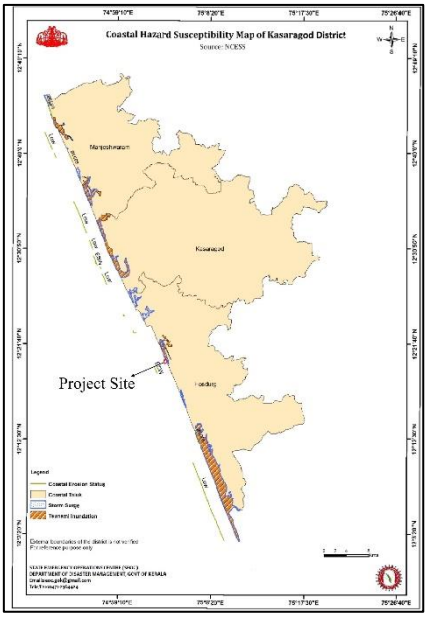


Source: DDMP 2015, Kasaragod

Figure 3.34: Flood Susceptibility Map

3.11.6 Coastal Hazard

As per the coastal hazard susceptibility map map of Kasaragod district prepared by NCESS for DDMP 2015, the project site falls in storm surge and tsunami inundation region. The coastal hazard susceptibility map is given in Figure 3.35.



Source: DDMP 2015, Kasaragod

Figure 3.35: Coastal Hazard Susceptibility Map

Chapter 4 Anticipated Impacts & Mitigation Measures

4.1 Environmental Attributes for Impact Assessment

The construction and operation of a fishing harbour in Ajanur, encompasses environmental attributes that may experience both positive and negative impacts, each with its own potential effects during the design, construction, operation, and decommissioning phases. The anticipated impacts from the proposed project are identified for the following major attributes of the environment:

1. Land Environment
2. Water Environment (*Surface water, Groundwater and Marine water*)
3. Air Environment
4. Noise and Vibration
5. Ecology and Biodiversity (*Species, Population, Habitats and Communities*)
6. Occupational Health and Safety
7. Socio-economic and Cultural
8. Climate (*Microclimate and Macro-climate*)

4.2 Stages of Project Implementation

The proposed project will be implemented in three distinct phases as depicted in Figure 4.1. The impacts on the various environmental attributes were assessed considering these three phases of the project with distinct impacts anticipated at each stage.



Figure 4.1: Phases of Project Implementation

4.3 Anticipated Impacts and Mitigation Measures: Pre-construction and Design Phase

The anticipated environmental impacts of the project in construction as well as operation phase can be mitigated, if adequate measures are adopted in the design and pre-construction stage of the project by integrating safety and environmental considerations into the project design and by adequate planning for implementation of the project. The anticipated environmental impacts and the corresponding mitigation measures which can be adopted in pre-construction and design phase are listed in Table 4.1.

Table 4.1: Anticipated Impacts and Mitigation Measures: Pre-construction & Design Phase

Aspect	Anticipated Environmental Impacts	Mitigation Measures proposed
P.1 Design		
P.1.1 Design of breakwaters and harbour facilities	• If breakwaters are not efficiently designed to cater to the site conditions, it can lead to the environmental/ social impacts	• The design shall be implemented as per the recommendation of model study of CWPRS. • The engineering design and materials for constructions shall be selected appropriately suiting for the location and the need of the project.

Aspect	Anticipated Environmental Impacts	Mitigation Measures proposed
		• Regular maintenance and repair of breakwaters shall be proposed for the effective coastal protection.
P.1.2 Design for safety against natural hazards		
P.1.2.1 Costal Hazard	• Possible damage to life, property and environmental attributes from the deposition of sediments at harbour mouth and river mouth. • Erosion of land resulting in loss of beach land.	• Design of structures was done considering relevant environmental parameters. • The breakwaters and river training walls were designed according to the recommendation of model study to provide a tranquil harbour basin and stable river mouth. • Maintenance dredging is proposed in the model study for maintaining adequate basin depth and depth in the river mouth. • Construction materials that are suitably selected to be storm- and corrosion-resistant.
P.1.2.2 Earthquake	• Kerala falls in Seismic Zone III • Possible damage to life and property from earthquakes	Relevant IS code (IS: 1893 – 1984) shall be adopted in designing the structure to sustain the magnitude of earthquake corresponding to Zone III.
P.1.2.3 Cyclone	• The site falls under moderate damage risk zone B (the basic wind speed, Vb = 39 m/s), as per the Wind and Cyclone Hazard Map of India. • Possible damage to life and property from cyclones	Relevant IS 15498 (2004): shall be adopted in designing the structure to sustain the magnitude of the cyclone corresponding to moderate zone.
P.2 Site selection of various facilities and equipment		
P.2.1. Location of storage of materials, construction equipment, vehicles, machinery, etc.	• There can be dust emissions or leakages leading to air, water or soil pollution if the storage areas are not carefully planned and located. • Accidental spillages can affect the health of construction workers/local population and marine life	• The storage locations should be clearly demarcated, and warning signboards shall be erected, especially in the case of storage of hazardous chemicals and avoid locations near sensitive coastal zones. • Fuel storage and refuelling sites to be at pre-designed location and kept away from the shoreline. • Preventive measures shall be strictly followed to avoid accidental spillage of fuels and in case of any accidental spillage, proper

Aspect	Anticipated Environmental Impacts	Mitigation Measures proposed
		measure shall be taken, like secondary containment.
P.3 Statutory Approvals and Permits		
P.3.1 Obtaining the necessary Statutory Clearances, Approvals and Permits	Not obtaining the statutory approvals leads to non-compliances or violations of environmental norms	Statutory clearances shall be obtained which includes CRZ Clearance, NOCs from Fire and Rescue Services, consent from PCB etc.
P.4 Identification of sources of resources		
P.4.1 Quarries	• Transporting granite from unauthorized quarries. • Over extraction of rocks for the construction purposes can impose adverse effects.	Granite stones shall be purchased from quarries having valid EC as per the requirement of the construction through lorries/ tippers.
P.4.2 Water for Construction	Withdrawal of groundwater from CRZ areas will result in saltwater intrusion	• Drinking water required for the construction workers will be sourced from nearby drinking water suppliers in tankers. • Open well proposed to be used as one of the sources of fresh water is selected from outside CRZ area. No withdrawal of groundwater from CRZ area is proposed.
P.4.3 Workforce for construction	Not providing job opportunities for local population can create unrest and can lead to conflicts between the construction workforce and local population	The skilled/ trained workforce shall be deployed from the local population for the construction and operational activities.
P.5 Preparation of Environmental Management Implementation Plan		
P.5.1 Comprehensive Solid Waste Management Plan	Inadequate waste management measures lead to pollution of the environment and can cause inconvenience to the local population.	• Comprehensive Solid Waste Management Plan shall be prepared to include the following, o Construction waste management o Solid, Hazardous and E-waste management • Locations for temporary storage of all biodegradable, non-biodegradable and hazardous waste shall be demarcated.

Aspect	Anticipated Environmental Impacts	Mitigation Measures proposed
P.5.2 Construction Schedule	• Construction activities if not carried out as per the schedule can cause project cost escalation • Construction during the monsoon season can cause water pollution due to leaching of chemicals from constructions materials/ wastes, etc.	• The detailed construction schedule for 48 months shall be prepared before the commencement of the construction activities. • All the construction activities shall be suspended during heavy rains and rough tide days.
P.6 Preparation of Standard Operating Procedures (SOPs)		
P.6.1 Preparation of SOPs	Environmental degradation & inconvenience to the public if suitable construction methodologies aren't adopted.	• SOPs based on best engineering practices shall be prepared for construction of breakwaters, and the harbour facilities. • Create SOPs for handling accidental spills or leaks, especially during fuel handling or chemical storage, to ensure quick and effective response.
P.7 Implementation - Information Meetings		
P.7.1 Implementation - Information Meetings and Orientation Training	There can be local resistance to the construction activities, if the public is not made aware of the various aspects of construction such as provisions for beach landing, traffic management for construction vehicles, construction schedule, any safety risks to local population, etc.	• At least two implementation information meetings shall be organized for general public, to consult and inform people about the plans covering overall construction schedule, safety, traffic safety and management plan, measures to minimize disruption, damage and in convenience to locals. • The people should be informed about the date, time and venue at least 7 days prior to meetings. • Set up grievance redressal system where the local population can report issues or concerns during construction and operation phase. A dedicated hotline or email can be made available to ensure swift action.

4.4 Anticipated Impacts and Mitigation Measures during the Construction Phase

The impacts during the construction phase can arise from the various construction activities such as the procurement/ transportation/ storage of construction material, movement and operations of various machinery/ equipment/ vehicles, construction works in the water body etc. There can be inconveniences

to the fishers, current users of the area and local public, if proper management plans are not implemented for navigation. Management of solid and liquid waste can affect both the environment as well as the public. The anticipated impacts in the construction phase and the corresponding mitigation measures to be adopted during preparatory activities of the construction phase are depicted in Table 4.2

Table 4.2: Anticipated Impacts & Mitigation Measures: Construction Phase

Aspect	Anticipated Environmental Impacts	Mitigation Measures proposed
C.1. Preparatory Activities		
C.1.1 Preparatory Activities	If the environmental implementation plan with roles and responsibilities for execution are not finalized before the start of constructions, field implementation of the EMP may not happen as envisaged, resulting in environmental degradation and inconvenience to the local population.	Defining the roles and responsibilities of the various stakeholders for implementation of the EMP before the commencement of the constructions.
C.1.2 Temporary storage area	• Nuisance to the fishers due to occupying their anchoring area for storage of construction materials/ equipment. • Air and noise pollution during the transport, storage and handling of the materials.	• The storage area shall be identified with minimal disturbance to the beach users, fishers and local public. • Communicate with fishers and providing them with advance notice of construction activities • Necessary warning signs/ boards of storage materials and heavy machinery, safety barricades shall be placed at necessary spots.
C.1.3 Planning for Traffic Changes	• Increased traffic during construction phase will disturb the other road users and the fish sales. • Air and noise pollution from the vehicles.	• The navigation path for the construction material shall be finalized in consultation with the representatives of the fisher's community. • Traffic Management Plan shall be implemented. It shall contain details such as diversions, if any; traffic safety arrangement during construction and precautions for transportation of materials. • Install speed limit signs around the construction zones and enforce low-speed limits for construction vehicles to reduce noise and dust generation.

The anticipated environmental impacts can be specific to certain environmental attributes with specific mitigation measures required for mitigating such impacts, in addition to the mitigation measures adopted in the pre-construction phase. The following sections describe the specific anticipated impacts and mitigation measures on land environment, water environment (surface water, groundwater and marine water), air environment, noise and vibration levels, ecology and biodiversity, occupational health and safety, socio-economic and cultural environment, climate and restoration & rehabilitation.

4.4.1 Land Environment

The anticipated impacts in the construction phase on the land environment and the corresponding mitigation measures to be adopted are depicted in Table 4.3.

Table 4.3: Anticipated Impacts & Mitigation Measures on Land from Construction

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.1 Activities with Impact on Land Environment		
C.2.1 Earth excavation and land clearance.	Excavation into the land and land clearance alters the structural stability and characteristics of the earth	• The excess excavated earth shall be used for filling the foundation trenches of harbour facilities. • Limit vegetation clearing to necessary areas.
C.2.2 Constructions near CRZ areas	Construction activities if undertaken without diligence, can lead various pollutants finding their way into the land.	• Construction in and near the water bodies shall be done as per the SOPs prepared. • The construction activities in and near water bodies shall be suspended during rough tides and heavy rains • The construction site shall be cleared of any debris/ construction waste and restored to its original state after completion of the construction activities
C.2.3 Contamination of sediment/soil due to leakage/ spillage of oil, construction spoils generated from construction.	• Leakage or spillage can cause land/ soil/ water pollution which will have serious repercussions on the soil quality. • Waste generated by construction workers	• The locations identified in the preconstruction/ design phase shall be used for the storage of construction equipment/barges, fuel, etc. • Designate impermeable storage for chemicals, establish runoff control and drainage systems. • Construction equipment shall be well maintained and refueled impervious platform with provision of garland channel to collect any oil and fuel spillage. • Waste oil and oil-soaked cotton/ cloth shall be stored in containers labeled ‘Waste Oil’ & ‘Hazardous’ and sold off to authorized vendors

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
		• Storage of empty and filled barrels/ drums of oil and fuel at earmarked area as per the Comprehensive Waste Management Plan. Empty barrels will be returned to authorized vendors. • Oil Spill containment kits (Including Absorbent Pads, Absorbent Socks, Disposable Bags, Safety Goggle etc.) shall be made available at site in order to manage any accidental spills on to land. • Biodegradable waste generated by the workers shall be managed using bio bins at the site. • Implement regular inspections and maintenance of fuel storage areas and spill kits on-site to handle accidental spillage promptly.
C.2.4 Coastal Protection	Impacts on the coastal area include: • Alteration of coastal landscape • Impacts on beach access • Land use conversion	• The construction of breakwaters for protecting shorelines, harbour, and coastal structures from the effects of waves and storm surges. • Implementation of beach reclamation and restoration programs post-construction. • Consult with the local fishing community to balance development needs with the preservation of the natural land used for fishing activities.

4.4.2 Water Environment (Surface, Groundwater and Marine water)

To identify the impacts on water environment, calculation of Water Quality Index (WQI) was done based on the monitored baseline data.

4.4.2.1. Water Quality Index

WQI was calculated using the monitored water quality parameters at surface water sampling location. The calculated WQI results are given in Table 4.4.

Table 4.4: WQI calculated as per the Water Quality Monitoring Results

Location Code	Calculated WQI	WQI Category
SW1	53.69	Medium

According to the standards of National Sanitation Foundation, USA in 1970, the WQI at monitored location indicate that the water quality was 'Medium' during the monitoring period. Therefore, necessary mitigation measures for the water environment shall be undertaken to maintain the quality of water.

4.4.2.2. Anticipated Impacts and Mitigation Measures proposed for Water Environment

The anticipated impacts in the construction phase on the water environment and the corresponding mitigation measures to be adopted are depicted in Table 4.5.

Table 4.5: Anticipated Impacts & Mitigation Measures on Water from Construction

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.2.1 Activities with impact on Surface Water		
C.2.1.1 Water requirement for construction	• Wastage of water • Drawing of excess fresh water	• Water for construction activities will be purchased in tankers. • Only required quantity of water shall be brought to site. • Best construction practices shall be adopted to minimize the water consumption such as reusing water for curing, etc. • Obtain necessary approvals for consumption of the water.
C.2.2 Activities with impact on Ground Water		
C.2.2.1 Sourcing of groundwater	• The proposed project falls in CRZ area, hence groundwater withdrawal result in salt water intrusion.	There shall not be any groundwater withdrawal from CRZ areas.
C.2.3 Activities with impact on Marine Water		
C.2.3.1 Construction activities leading to alterations to marine water flow	• Alteration to natural tidal pattern of the sea leading to erosion on the northern side of the proposed project	Well-designed breakwaters are proposed to avoid effects of erosion at the northern end of the beach.
C.2.3.2 Water Pollution from Construction Activities	The construction activities can pollute the marine water bodies: • Disposal of wastewater from construction activities into the sea • Leakages from machineries and vehicles leading to water pollution.	• No wastes shall be disposed into the sea. • Fuel storage and refueling sites to be at pre-designed impermeable storage location and kept away from the shoreline. • Oil Spill containment kits (Including Absorbent Pads, Absorbent Socks, Disposable Bags, Safety Goggle etc.) shall be made available at the site for immediate response to accidental spills. • Portable STP for management of wastewater generated by construction workers

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
	• Contamination due to surface water runoff of fuels, oils, etc. used for the construction activities • Disposal of construction wastes and other solid wastes • Wastewater generation by the construction workers • Increase in turbidity due to dredging.	• Drip pans shall be provided for the DG sets and other machineries. • All construction equipment/machinery shall be stored on paved or impermeable surface. • Waste oils and fuels shall be stored in closed cans, barrels, etc. • Refueling of machines/ vehicles/ equipment shall be done only at designated locations away from the shore • A detention tank shall be provided to collect surface runoff from the construction site and only overflow from this tank shall be discharged to water bodies or public drain. • Proper facilities for the source segregation and adequate management of solid waste shall be practiced at the construction site. • The turbidity levels during maintenance dredging should be measured and checked with the baseline as a reference. If turbidity spreads beyond the area earmarked for dredging, the operation should be suspended until baseline is attained.

4.4.3 Air Environment

To identify the impacts on air environment, calculation of Air Quality Index (AQI) was done based on the monitored baseline data.

4.4.3.1. Air Quality Index

AQI was calculated using the AQI Calculator available in the CPCB website. 24-hour average value of the monitored pollutants at each baseline ambient air sampling locations were taken while calculating the AQI. The calculated AQI results are given in Table 4.6.

Table 4.6: AQI Calculated as per the Baseline Ambient Air Quality Monitoring Results

Location Code	Calculated AQI	AQI Category
AQ1	69	Satisfactory
AQ2	63	
AQ3	74	

From the AQI calculations, it is observed that AQI at the baseline ambient air monitoring locations ranged between 63 – 74 during the monitoring period. AQI at all monitored locations indicate that the air quality was 'Satisfactory' according to the National Air Quality Index (NAQI). The AQI ranging

from 51 – 100 may cause minor breathing discomfort to sensitive people and therefore, necessary mitigation measures for the air environment shall be undertaken.

4.4.3.2. Anticipated Impacts and Mitigation Measures proposed for the Air Environment

The anticipated impacts in the construction phase on the air environment and the corresponding mitigation measures to be adopted are depicted in Table 4.7.

Table 4.7: Anticipated Impacts & Mitigation Measures on Air from Construction

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.3 Activities with impact on Air Quality		
C.3.1 Emissions due to construction activities	• Emissions from construction vehicles, machinery, equipment, DG sets, etc. • Burning of garbage and waste lead to air pollution, and discharge of highly toxic emissions • Fugitive dust emissions anticipated from unloading/ handling of construction material, storage of construction material, movement of vehicles over unpaved roads, etc. • Dust and emissions may persist at higher levels due to extended construction activities.	• Low-emission construction equipment shall be used for construction activities and they should be regularly maintained. • Construction equipment & vehicles shall be turned off when not used for extended period of time. • Regular maintenance of vehicles and use of vehicles with approved PUC • Adequate stack height shall be provided for DG sets. • The burning of garbage and waste shall not be permitted. • Dust barriers shall be used for dust from spreading.
C.3.2 Emissions due to transportation of construction materials	Air pollution due the movement of vehicles	• Regular maintenance of vehicles and use of vehicles with approved PUC • Dust barriers shall be used for dust from spreading • Transporting construction materials in covered vehicles • Unnecessary idling of construction vehicle shall be prohibited.

4.4.4 Noise and Vibration Levels

Noise generation during the construction phase will be due to the operation of machineries. The anticipated impacts in the construction phase on the noise levels the corresponding mitigation measures to be adopted are depicted in Table 4.8.

Table 4.8: Anticipated Impacts & Mitigation Measures on Noise Levels from Construction

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.4 Activities with impact on Noise and Vibration Levels		
C.4.1 Construction activities such as drilling, grinding etc.	Noise and vibrations from are anticipated from : • Operations and movements of construction equipment/ machinery and barges. • Unloading of material. • Construction activities Prolonged noise pollution causing disturbance to nearby communities and marine species	• All equipment, and machinery to be procured for construction confirming to the relevant Indian Standard (IS) norms and should be low noise machinery, as much as possible. • All vehicles deployed should have valid PUC and a record of the same shall be maintained. • All equipment used in construction shall strictly confirm to the MoEF&CC/ CPCB noise standards. • Vehicle and equipment inspection camps shall be conducted once in a year. • DG sets should be provided with acoustic enclosures. • Profile sheet barricades shall be provided around the proposed harbour facilities • Provide acoustic insulation and noise suppression around loud machinery. • Servicing of all construction machinery shall be done regularly and during routine servicing operations, the effectiveness of exhaust silencers will be checked and if found defective will be replaced. • Schedule high-noise activities to the day time only.

4.4.5 Ecology and Biodiversity

The anticipated impacts in the construction phase on ecology and biodiversity and the corresponding mitigation measures to be adopted are depicted in Table 4.9.

Table 4.9: Anticipated Impacts & Mitigation Measures on Ecology and Biodiversity

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.5 Activities with impact on Ecology and Biodiversity		
C.5.1 Construction of breakwater, pile driving, dredging etc. affecting Terrestrial/Aquatic flora/fauna and	• Refugee space for small fishes, crabs etc. may be affected • Reduced faunal abundance and diversity due to poor quality of water, caused by the seepage of pollutants.	• Trainings/ awareness sessions to workers about marine ecosystem and to prevent littering. • Immediate removal of construction debris and site clearance shall be done.

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
Avifauna (species and habitat)	• Oil spillage can lead to loss of life in fauna and reduced productivity of flora (eg. Hypothermia in sea dwelling creatures) • Impact of plastic wastes on fauna (e.g., birds, turtles, fishes etc.), which can cause starvation, loss of life, suffocation, reduced mobility etc. • Selection of unsuitable location and species for green belt development.	• Limit the construction work within proposed site and minimize use of land/ vegetation outside of the depicted construction area. • Proper solid waste management. • Safe disposal of oil, oily mixtures, and other residues. • Green belt development with suitable species to reduce the negative impacts due to construction phase.

4.4.6 Occupational Health and Safety

The anticipated impacts in the construction phase on occupational health and safety and the corresponding mitigation measures to be adopted are depicted in Table 4.10.

Table 4.10: Anticipated Impacts & Mitigation Measures on Occupational Health& Safety

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.6 Activities with Impact on Occupational Health and Safety		
C.6.1 Potable water	The workers should be provided with potable water, else it causes health risks to construction workers from contaminated water	• It shall be ensured that uncontaminated water is available for drinking • Potable water facilities shall be provided for the workers • Conduct periodic inspections to ensure potable water meets health standards.
C.6.2 Sanitation and Sewage System	Workers should be provided with sanitation and wastewater management systems, else it causes : • Unsanitary conditions at the site • Stagnation of wastewater leading to spread of disease carrying vectors.	The following shall be ensured: • Toilets shall be provided for the construction workers at the site • Adequate water supply is to be provided in all toilets and urinals • The sanitation facilities are to be cleaned and kept in a strict sanitary condition to maintain hygiene. • Portable STP for the treatment of wastewater.
C.6.3 Safety of Workers and accident	The lack of adequate safety measures/training/PPEs causes	• The construction workers shall be given adequate training on HSE policy, Emergency Response and Disaster Management Plan (ERDMP), SOPs for construction, etc.

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
risk from construction activities	• Accidents like falling from heights, into the sea, etc. affecting lives and property • Non-compliance to safety regulations. • Sunburn • Weather related calamities. • Increased risk of accidents due to unattended and properly demarcated unfinished areas.	• Appoint a dedicated on-site Health, Safety and Environment (HSE) officer to oversee daily activities and ensure that safety protocols are followed rigorously • The workers should be trained to ensure the use of appropriate PPE depending on the task. All PPE should be checked regularly and before use. Routine trainings to be conducted. • Imposing strict rules and procedures for the execution of specific tasks, enforcement of the applicable Acts and Rules on workforce welfare and compensation. • Appropriate lighting shall be provided if any constructions are undertaken during the night. • Proper caution signage, barricading etc. shall be installed at construction zone. • Trespassing of the local public into the construction site shall be restricted to prevent accidents. • All the construction activities shall be suspended during heavy rains. • Establishment of early warning systems shall be proposed to minimize the effect of such natural calamity in the future. • First aid facilities with adequate number of first-aid-trained staff should be available at site. Tie up with nearest hospital or health care center shall be established to manage an emergency. • Providing water ambulances near/ in the proposed construction site for immediate use. • Medical check-up camps for workers, shall be arranged once in six months.

4.4.7 Socio-economic and Cultural

The anticipated impacts in the construction phase on socio-economic and cultural environment and the corresponding mitigation measures to be adopted are depicted in Table 4.11. No land acquisition performed for the project; therefore, there is no requirement of R&R Plan.

Table 4.11: Anticipated Impacts & Mitigation Measures on Socio-economic & Culture

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C. 7 Activities with Impact on Socio-Economic and Cultural Environment		
C.7.1 Risk to local community/ public	• Inconvenience to the public from air, noise, water, and soil pollution, especially due to the constructions • Potential interruption of local fishing and access for the community.	• All mitigation measures suggested for preventing air, noise, water, and soil pollution shall be scrupulously followed. • Coordinate with fishing communities, provide alternate access routes, and regularly update community on progress. • Inform the local population prior to the commencement of construction activities through visual and print media. • Grievance redressal system shall be established for the public and it should be ensured that the grievances are addressed in a prompt and sustainable manner. • The siting criteria for construction equipment/ machinery/ storage locations/ casting yards etc., shall be scrupulously followed. • Heavy noise generating activities shall be scheduled during day time
C.7.2 Traffic management	Inconvenience to the public due to the traffic congestion.	• A prescribed time period for the movement of trucks or restricting their movement during the rush hours (early morning, evening school and office hours). • Communicate with local communities, schedule activities to minimize disruption.

4.4.8 Climate (Microclimate and Macro-climate)

The anticipated impacts in the construction phase on the climate change and the corresponding mitigation measures to be adopted are depicted in Table 4.12.

Table 4.12: Anticipated Impacts & Mitigation Measures on Climate from Constructions

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.8 Activities with impact on Climate Change		
C.8.1 Greenhouse gases (GHG) emissions	Minor microclimate impact due to: • Operations of various construction equipment/	• Fuel efficient equipment/ machineries/ other electrical devices shall be used for the construction activities. • Trip scheduling shall be adopted for the construction materials

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
	machinery and other construction activities • Transportation of construction material • Power consumption	• Shuttle bus services shall be provided for the construction workers. • LED lights shall be used for all lighting requirements. • Stick to the construction schedule and minimize extending duration of activities to reduce impact. • Establish green belts or plant buffers around the site to reduce impacts on the microclimate.

4.4.9 Clean up Operations, Restoration and Rehabilitation

The anticipated impacts in the construction phase from the clean-up operations and the corresponding mitigation measures to be adopted are depicted in Table 4.13.

Table 4.13: Anticipated Impacts & Mitigation Measures for the Clean-up Operations

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
C.9 Clean-up Operations, Restoration and Rehabilitation		
C.9.1 Clean-up Operations, Restoration and Rehabilitation	• Environment degradation • Safety hazards and inconveniences to the local population	• The clean-up and restoration operations are to be implemented, prior to demobilization. • All construction zones including the breakwaters, and harbour area shall be cleaned up. • Coordinate with local environmental agencies to ensure that cleanup efforts meet or exceed regulatory standards, and restore native vegetation to disturbed areas to promote ecosystem recovery.

4.5 Anticipated Impacts and Mitigation Measures during the Operation Phase

The project is proposed as a solution for the pressing needs of the local fishers caused by the migratory river mouth and insufficient fish landing facilities. The following sections describe the specific anticipated impacts and mitigation measures on land environment, water environment (marine water, surface water and groundwater), air environment, noise and vibration levels, ecology and biodiversity, occupational health and safety, socio-economic and cultural environment, climate and restoration & rehabilitation.

4.5.1 Land Environment

The anticipated impacts in the operation phase on the land environment and the corresponding mitigation measures to be adopted are depicted in Table 4.3.

Table 4.14: Anticipated Impacts & Mitigation Measures on Land from Operations

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.1 Activities with Impact on Land Environment		
O.1.1. Probability of erosion on south of project site and increased sedimentation	• Loss of beach land • Effects on structural stability of existing and proposed structures • Altered coastal landforms and erosion patterns.	• Regular monitoring of land erosion and deposition patterns shall be done by continuous shoreline mapping by HED and additional mitigation measures shall be adopted as required. • Implement coastal management strategies to preserve beach areas. • If the erosion on the south side of the proposed fishing harbour is progressive after the development, then a suitable shore protection measure in the form of a seawall or series of groynes may be provided as per the suggestions of CWPRS.
O.1.2. Contamination of land with solid/liquid waste and land degradation	• Disposal of untreated solid and liquid waste from harbour onto land can cause soil contamination. • Increased foot traffic, waste accumulation degrades land.	• Implement a waste management plan, designate waste disposal areas, conduct regular maintenance on landside facilities of the harbour. • Garbage bins shall be provided in the site and ensure that these are regularly emptied and disposed in a hygienic manner. • On-site decomposition of biodegradable waste shall be adopted with the help of aerobic composting bins. • All recyclables shall be handed over to respective recyclers. • All other non-biodegradable wastes shall be handed over to authorized waste handlers. • ETP of 15 kLD will be provided at the harbour. • The proposed ETP shall be regularly inspected and maintained. • Ensure workers are trained on proper waste segregation to enhance compliance with disposal standards.
O.1.3 Leakage/ spillage of hazardous waste	• Spillage/ leakage of oil, diesel etc. from vehicles and equipment.	• Fuel used for machineries/ fishing vessels shall be stored in designated area having impervious paved floor and waste oil shall be stored in barrels. • The machineries used at site for the fish handling shall be regularly inspected and maintained. • Waste oil from DG sets or other equipment shall be disposed through authorized dealers as per the

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
		Hazardous and Other Waste (Management & Transboundary Movement) Rules, 2016.

4.5.2 Water Environment (Marine, Surface and Groundwater)

The anticipated impacts in the operation phase on the water environment and the corresponding mitigation measures to be adopted are depicted in Table 4.5.

Table 4.15: Anticipated Impacts & Mitigation Measures on Water from Operations

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.2 Activities with impact on Water Environment		
O.2.1 Increased water requirement at the harbour facilities.	• Stress on the fresh water source due to over exploitation and wastage of water • Withdrawal of groundwater from CRZ areas.	• It is proposed to install RWH tanks of 50 kL at the harbour. • The treated water from the ETP shall be reused for landscaping area. • Additional water requirement than the stored water from the pump house and identified open well shall be met from water purchased via tankers. • Withdrawal of groundwater shall be strictly prohibited in CRZ areas. • Install water-saving fixtures in harbour restrooms and fish handling areas to optimize water use and further reduce demand.
O.2.2 Contamination of the waterbody	• Spillage of fuels from mechanized boats • Disposal of waste nets, etc. by fishers into the sea • Disposal of wastewater into the waterbody.	• Fishers shall be given awareness on conservation of environment, keeping their boats and equipment clean, etc. • Fuel used for machineries shall be managed as per the Hazardous and Other Waste (Management & Trans boundary Movement) Rules, 2016. • Untreated wastewater shall not be disposed to the waterbody. • Provide dedicated disposal bins near berthing areas to encourage fishers to dispose of nets and waste properly, rather than into the sea.
O.2.3 Storm water management	• Contamination of waterbody due to direct runoff from	• Detention tank shall be provided before letting the storm water in the drain from discharging into the waterbody.

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
	landside facilities of the harbour into the waterbody • Water logging can occur if adequate provisions for drainage is not provided. • Altered coastal hydrodynamics affecting marine ecosystems. • Changes in sedimentation patterns may affect water quality in nearby water bodies.	• The drains and detention tanks shall be desilted and maintained regularly, especially before the onset of monsoon.

4.5.3 Air Environment

The anticipated impacts in the operation phase on the air environment and the corresponding mitigation measures to be adopted are depicted in Table 4.16.

Table 4.16: Anticipated Impacts & Mitigation Measures on Air from Operations

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.3 Activities with impact on Air Quality		
O.3.1 Emissions due to movement of vehicles and working of machinery	• Air pollution due the emission from vessels and trucks due to inadequate berthing, parking and movement facilities. • Deterioration of the quality of the access road. • Emissions from DG sets (backup power source) and other machineries.	• Only vehicles having valid PUC shall be allowed into the harbour. • The internal road and parking areas of the harbour shall be regularly maintained. • DG sets shall be installed as per CPCB guidelines and shall have adequate stack height. • Regular equipment & vehicle emission inspection program and incentivize staff to use low-emission vehicles or carpool to the harbour.

4.5.4 Noise and Vibration Levels

The anticipated impacts in the operation phase on the noise and vibration levels and the corresponding mitigation measures to be adopted are depicted in Table 4.8.

Table 4.17: Anticipated Impacts & Mitigation Measures on Noise & Vibration

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.4 Activities with impact on Noise and Vibration Levels		
O.4.1 Increased noise levels in the harbour premises	Generation of Noise Level due to: • Increased movement of fishing vessels and other operational activities • Movement of trucks to the harbour • Functioning of equipment and DG sets	• Acoustic enclosures for DG Sets and other noise generating machineries as per CPCB guidelines shall be provided • Proper lubrication, muffling and modernization of equipment shall be used to reduce the noise during operation phase. • Vehicle and equipment inspection camps shall be conducted to ensure that they are operating as per the prevailing norms for controlling pollution.

4.5.5 Ecology and Biodiversity

There will not be any adverse impact on terrestrial ecology during operation phase of the project. The anticipated impacts in the operation phase on the marine ecology and biodiversity and the corresponding mitigation measures to be adopted are depicted in Table 4.9.

Table 4.18: Anticipated Impacts & Mitigation Measures on Ecology and Biodiversity

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.5 Activities with impact on Ecology and Biodiversity		
O.5.1 Increased movement of fishing vessels	• Long-term habitat changes due to breakwater and altered sedimentation patterns may threaten local marine species. • Increased movement of fishing vehicles threatening the habitat degradation/ fragmentation of marine organisms. • Loss/ disturbance to breeding, nesting, spawning areas	• Fishing vehicles shall be anchored at designated nearest feasible location. • Designate specific routes for marine vessels to reduce the risk of accidental collisions with sensitive habitats. • Impose speed restrictions in areas where marine life is concentrated to minimize disturbances.
O.5.2 Over exploitation of fishes and	Stress on the number and species of fishes available in the sea.	• Awareness trainings shall be given to fishers about the latest state-of-the-art fishing methods to avoid

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
other organisms in the sea		trapping of species that need environmental protection and against overfishing. • Coordinate with local fisheries organizations to promote and support programs for sustainable fishing practices. • Temporary bans on fishing during breeding or migratory periods.
O.5.3 Introduction of non-native species into the local ecosystem	Invasive species can disrupt the balance of the local marine ecosystem, potentially leading to the decline or extinction of indigenous species.	Establish regular monitoring and inspection programs to detect invasive species early and implement rapid response actions to eradicate them before they become established.
O.5.4 Green area development	• Selection of unsuitable location and species for green area development. • Lack of maintenance of green area	• The species for green area development shall be selected in consultation with locals. • Develop a long-term green area maintenance plan with community involvement to ensure sustainable growth and restoration of these green belt areas.

4.5.6 Occupational Health and Safety

The anticipated impacts in the operation phase on occupational health and safety and the corresponding mitigation measures to be adopted are depicted in Table 4.10.

Table 4.19: Anticipated Impacts & Mitigation Measures on Occupational Health & Safety

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.6 Activities with Impact on Occupational Health and Safety		
O.6.1 Sewage disposal system and sanitation	• Contamination of drinking water sources • Inadequate sanitation and wastewater management systems • Spread of waterborne communicable diseases • Mosquito/ pests menace	• Adequate sanitation facilities for workers with adequate water supply are proposed along with resting rooms at the harbour, which shall be cleaned and kept in a safe sanitary condition. • HSE in charge of HED shall be appointed for conducting daily inspections regarding the safety and hygiene conditions at the harbour.

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.6.2 Solid Waste Disposal	The lack of solid waste management systems causes: • Environmental pollution • Unhygienic conditions and menace of stray dogs/ pests • Risks of spread of communicable diseases.	• Source segregation and management of solid waste. • The harbour premises shall be kept in good conditions and measures to control pest shall also be undertaken. • Regular inspections should be conducted to ensure compliance with waste management practices, and staff should receive training on waste disposal to minimize environmental pollution.
O.6.3 Accident risk from fishing in the sea and daily operations.	The lack of adequate safety measures/ training/ PPEs causes • Accidents affecting lives and property. • Harm to life of fishers due to failure of equipment. • Unable to return safely on time to the harbour	• Accurate warning systems shall be provided to warn the fishers about the weather/ environmental conditions. • Fishers shall be provided training and instructions to wear adequate PPE. • Fishers shall also be instructed to obtain appropriate insurances. • Enough staff trained in first aid measures and all necessary facilities shall always be deployed at the harbour. Safety trainings, maintaining first-aid kits of adequate numbers and emergency response facilities, and provide continuous PPE access. • Periodic medical check-ups for the fishers and the workers at the harbour shall be conducted.

4.5.7 Socio-economic and Cultural

The anticipated impacts in the operation phase on socio-economic and cultural environment and the corresponding mitigation measures to be adopted are depicted in Table 4.11. No land acquisition performed for the project; therefore, there is no requirement of R&R Plan.

Table 4.20: Anticipated Impacts & Mitigation Measures on Socio-economic & Culture

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O. 7 Activities with Impact on Socio-Economic and Cultural Environment		

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.7.1 Inadequacy of facilities provided in the harbour	Influx of large number of customers to the landside facilities of the harbour creating rush at the harbour and large competition for the local customers.	• The adequacy of the landside facilities shall be evaluated from time to time. The facilities shall be augmented as per requirement. • Create visitor guidelines and install information boards to educate visitors on best practices to minimize their impact on harbour operations.
O.7.2 Traffic management	Inconvenience to the local public due to the increased movement of trucks used for transportation of fishes to the nearest market and customers.	• Traffic Management Plan shall be prepared and scrupulously followed. • Traffic warden shall be appointed in order to maintain traffic inside the harbour. • Vehicular trips for the transportation of fishes shall be scheduled to ensure smooth flow of traffic and shall not cause inconvenience to local public.

4.5.8 Climate (Microclimate and Macro-climate)

The anticipated impacts in the operation phase on the climate change and the corresponding mitigation measures to be adopted are depicted in Table 4.12.

Table 4.21: Anticipated Impacts & Mitigation Measures on Climate from Constructions

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
O.8 Activities with impact on Climate Change		
O.8.1 Activities with emissions of Greenhouse gases (GHGs)	GHG emissions from • Power requirement for the harbour operations • Operations of various equipment/ machinery • Truck movement for transportation of fishes to nearby markets and customers.	• Solar panels of capacity 30 kW are proposed to meet the power requirement of the harbour. • Smart energy management systems are proposed be used to monitor and optimize energy use in real-time, reducing overall GHG emissions. • Fuel efficient and star-rated equipment/ machineries/ other electrical devices shall be used for the operations, wherever applicable. • Only vehicles with valid PUC shall be allowed into the harbour.
O.8.2 Alter local microclimates	• Alter local microclimates through heat island effects (higher	• Increasing and maintaining vegetation and green areas.

Aspect	Anticipated Environmental Impacts	Mitigation Measures Proposed
through heat island effects	temperatures due to infrastructure and reduced vegetation). • Affect coastal weather patterns, exacerbating local temperature increases.	• Ensure regular maintenance of green spaces to maximize vegetation health and improve their effectiveness in cooling local microclimates.

4.6 Conclusions

From the above, it can be concluded that, the impacts due to the construction and operations of the harbour can be mitigated if appropriate management measures are implemented. There is a combination of project features that contribute in lowering anticipated impacts, which are:

- CWPRS has designed the breakwaters for the harbour and for river training works in accordance with modelling studies using the site-specific data and optimising the design as per the suggestions of HED after conducting necessary desk studies, for maximum efficient control over river mouth migration and for providing tranquil conditions in the harbour basin.
- The landside facilities of the harbour are proposed within the existing land of the harbour, which is under the possession of HED and therefore there is no requirement for land acquisition.
- The project includes environmental management measures such as wastewater treatment plant, improved stormwater drainage, rainwater harvesting, upgraded internal roads and expanded parking facilities.
- No tree cutting is proposed for the project and to improve the ecosystem, green area development and landscaping is included in the project.

Chapter 5 Analysis of Alternatives

5.1 No Project Scenario

The project is essential to address numerous challenges faced by local fishermen. The existing fish landing centre is inadequate, and the dynamic nature of the Chithari River mouth, characterized by sandbar formation and shifting channels, poses significant risks to both fishermen and property.

Without the proposed infrastructure improvements, the region will continue to face numerous challenges. Fishermen will remain exposed to safety risks, including accidents and economic losses due to damaged equipment and limited access to safe landing and berthing facilities. From an economic perspective, the absence of a dedicated harbour facility will limit the region's growth potential.

In conclusion, the "No Project" scenario could have severe consequences, emphasizing the urgent need for the implantation of the project.

5.2 Analysis of Alternative Site

The proposed site is almost equidistance from the existing harbours at Cheruvattur (17 km towards the south of project site) and Kasaragod (17 km towards north of project site). The site already has existing fish landing centre, auction hall, net mending shed, and toilet block and has the potential to be developed as harbour and hence no other site was considered for the development of harbour.

5.3 Analysis of Alternatives Design for Breakwaters

Various design and structural alternatives were evaluated to optimize the design of breakwaters.

The breakwater was initially designed with a 7 m wide, 0.5 m thick crest slab and a 0.5 m thick parapet wall. The seaward side of the breakwater has 2 T and 6 T tetrapod armour units, while the leeward side was armoured with lighter stones, ranging from 0.5 to 1 T and 1 to 2 T stones. The core constructed using 20–50 kg stones with a 0.3 m thick bedding layer of 20 kg stones comprised of 20–100 kg stones, supported by a 0.3 m thick bedding layer of 20 kg stones. The roundhead has 8T tetrapod on a 1:2 slope, supported by a 6 m wide toe berm made of 3– 4T stones, and included an 8 m wide carriageway for operational access.

Based on further refinements, the final design made minor modifications to improve cost-efficiency and structural performance. The crest width for the trunk section was reduced from 7.0 m to 5.5 m, while the roundhead crest width remained 8.0 m. For the -2.0 m bed level, the lee-side armour slope was adjusted to 1:1.5, and a toe berm composed of 0.5–1T stones was added at elevation +0.2 m. Similarly, for the -4.5 m bed level, the lee-side armour used 1–2T stones at a 1:1.5 slope, with a toe berm made of 1–2T stones at elevation -2.55 m. The roundhead toe berm was also adjusted, now composed of 3–4T stones placed at elevation -0.7 m. All other features of the initial design, including the materials, sea-side armour slopes, and bedding layers, were retained.

The initial design offered robust protection, with wider crest dimensions providing enhanced operational safety and hydraulic stability. However, the modifications in the final design optimized material usage, reducing costs while maintaining structural integrity.

Chapter 6 Environmental Monitoring Program

Environmental monitoring shall be carried out at the selected locations to assess the environmental quality which are useful for the following.

- To verify the predictions on environmental impacts.
- To ensure the proper implementation of suggested mitigation measures.
- To comply the requirements of environmental regulatory framework.
- To suggest for improvements or modifications in the Environment Management Plan.

Environmental Monitoring Program (EMoP) includes the performance monitoring for environmental attributes such as ambient air, noise levels, soil, surface water, groundwater, marine water etc. In order to protect the environment, manage and control pollution; monitoring systems and budgetary provisions would be required.

6.1 EMoP for Construction Phase

The EMoP for the construction phase shall be under the scope of the construction contractor. EMoP for the construction phase of the project is summarized in Table 6.1.

Table 6.1: EMoP for Construction Phase

S. No	Environment Component	Frequency of Monitoring	No. of Locations*	Compliance to Standards
1.	Ambient Air	24 hourly continuous monitoring twice in a year except monsoon	3	NAAQS, 2009
2.	Noise Levels	Day - 6 AM to 10 PM & Night -10PM to 6AM (24 hourly continuous monitoring) Once in every 6 months	3	Noise Pollution (Regulation & Control) Rules, 2000
3.	Marine Water Quality	Once in every 6 months	2	--
4.	Marine Sediments		2	--
5.	Surface Water		1	Surface Water Quality Standard based on Classification for Surface Water as per CPCB Guidelines
6.	Soil		1	--
** Locations for environmental monitoring shall be same as baseline environmental monitoring locations given in Chapter 3*				

The budgetary estimate of EMoP for construction phase is detailed in Table 6.2.

Table 6.2: Budgetary Estimate of EMoP for Construction Phase

S. No.	Particulars	No. of locations	Rate per location (INR)	No. of samples/year	Total Amount (INR)/ year
1.	Ambient Air	3	16,000	2	96,000
2.	Noise levels	3	7,000	2	42,000
3.	Marine water	2	8,000	2	32,000
4.	Marine sediment	2	10,000	2	40,000
5.	Surface water	1	8,000	2	16,000
6.	Soil	1	10,000	2	20,000
EMoP Budget for Construction Phase					**2,46,000**

6.2 EMoP for Operation Phase

The EMoP for the operation phase shall be under the scope of the HED. The budgetary estimate of EMoP for operation phase of the project is summarized in Table 6.3.

Table 6.3 Budgetary Estimate of EMoP for Operation Phase

S. No	Environment Component	Frequency of Monitoring	No. of Locations*	Compliance to Standards
For Environmental Aspects				
1.	Ambient Air	24 hourly continuous monitoring twice in a year except monsoon	3	NAAQS, 2009
2.	Noise Levels	Day - 6 AM to 10 PM & Night -10PM to 6AM (24 hourly continuous monitoring) Once in every 6 months	3	Noise Pollution (Regulation & Control) Rules, 2000
3.	Marine Water Quality	Once in every 6 months	2	-
4.	Marine Sediments		2	-
5.	Surface Water		1	Surface Water Quality Standard based on Classification for Surface Water as per CPCB Guidelines
6.	Soil		1	-
Environmental Monitoring for Project Facilities				
Proposed facilities				
1.	Inlet and outlet water from ETP	Once in every 6 months	2	-
2.	Stack Emissions		1	-
** Locations for environmental monitoring for Environmental Aspects shall be same as baseline environmental monitoring locations given in Chapter 3*				

The budgetary estimate for EMoP for operation phase is detailed in Table 6.4.

Table 6.4: Environment Monitoring Budget for Operation Phase

S. No.	Particulars	No. of locations	Rate per location (INR)	No. of samples/year	Total Amount (INR)/ year
For Environmental Aspects					
1.	Ambient Air	3	16,000	2	96,000
2.	Noise levels	3	7,000	2	42,000
3.	Marine water quality	2	8,000	2	32,000
4.	Marine sediment	2	10,000	2	40,000
5.	Surface water quality	1	8,000	2	16,000
6.	Soil quality	1	10,000	2	20,000
For Project Facilities: Proposed Facilities					
7.	Inlet and outlet water from proposed ETP	2	8,000	2	32,000
8.	Stack Emissions from DG sets	1	3,500	2	7,000
EMoP Budget for Operation Phase					**2,85,000**

The estimated cost for environmental monitoring during construction phase is **INR 2.46 Lakhs/year** and operation phase is **INR 2.85 Lakhs/year**. The monitoring of selected parameters for each half-year period shall be implemented through approved NABL Accredited Monitoring Agency.

Chapter 7 Additional Studies

7.1 Public Hearing

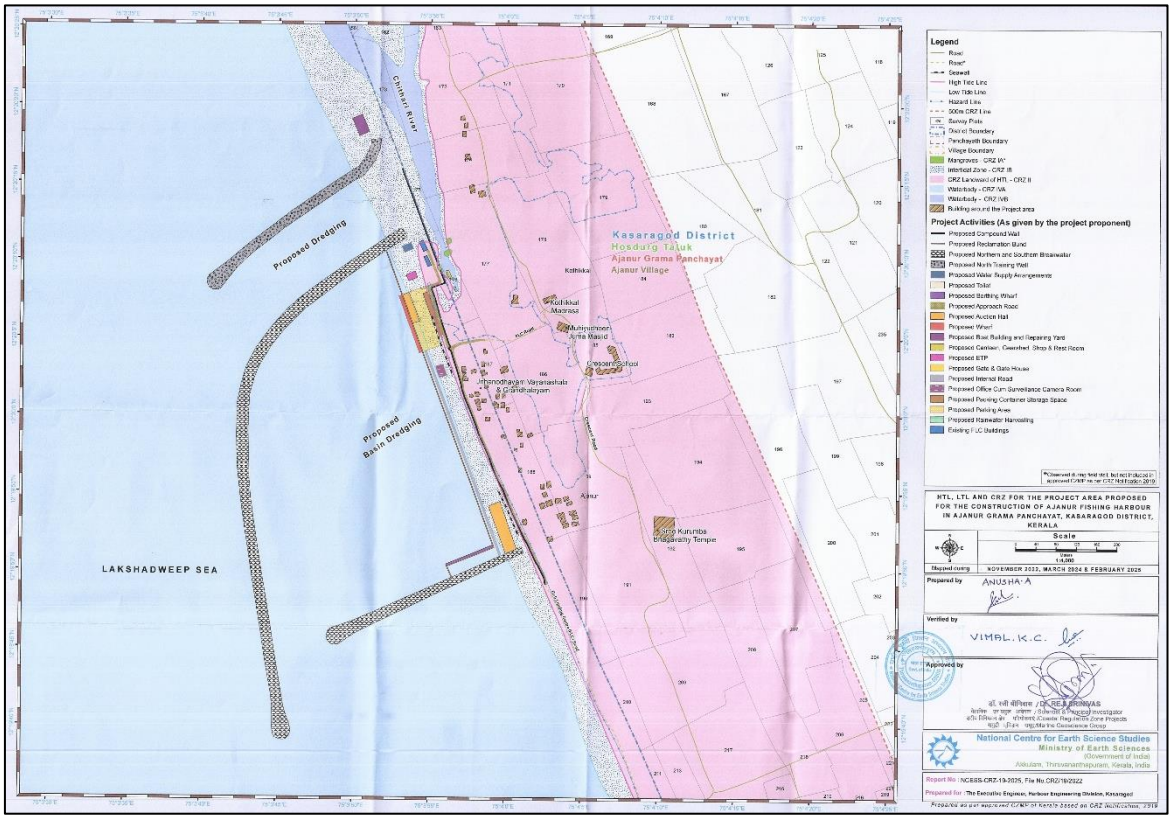
This project does not require public hearing as it is a standalone CRZ project.

7.2 Social Impact Assessment and R&R Action Plan

The existing social condition in the study area is detailed in section 3.10 of chapter 3 and the anticipated impacts on social environment and the mitigation measures suggested are detailed in section 4.4.7 and section 4.5.7 of chapter 4. Land acquisition is not involved for the proposed project and hence R&R action plan is not applicable.

7.3 HTL/LTL Demarcation

Detailed HTL/LTL demarcation studies for the project were conducted by National Centre for Earth Science Studies (NCESS), Thiruvananthapuram in accordance with CRZ notification, 2019. NCESS has prepared the CRZ Status Report and the HTL/LTL map in 1:4000 scale superimposing the project layout. The CRZ map for the proposed project prepared by NCESS is shown in Figure 7.1.



Source: CRZ Status Report

Figure 7.1: CRZ Map prepared by NCESS

As per the CRZ mapping, the proposed project falls within CRZ IA (Mangroves), CRZ IB (Intertidal Zone), CRZ II, CRZ-IV A (Lakshadweep Sea) and CRZ-IV B (Chithari River). Proposed construction of compound wall of 16.48 m falls within CRZ IA. HED decided not to proceed with the construction

of compound wall within CRZ IA. Other ecologically sensitive areas such as turtle nesting grounds or structures of archaeological importance and heritage sites, etc., which are categorised as CRZ IA, are not found in the project area or in its close proximity. The majority of the proposed project site is situated on the CRZ-IV A (Lakshadweep Sea), as per the CZMP map of Kerala. As per the clauses (i) & (ii) of section 5.1.2, (i) of section 5.2 and (ii) & (iii) of 5.4 of CRZ notification 2019, proposed activities are permissible in CRZ areas. The details of the proposed project site in CRZ area are given in Table 7.1.

Table 7.1: CRZ Details of Proposed Harbour

CRZ Zone	Length (m)	Area (m^2)
CRZ IA	16.48	-
CRZ IB	187.68	11,181.91
CRZ II	719.08	3,636.97
CRZ IVA	749.14	44,911.33
CRZ IVB	-	94.60
Total	**1,672.38**	**59,824.81**

Source: CRZ Status Report

7.4 Mathematical Modelling Studies

The CWPRS, Pune, conducted mathematical modelling studies to assess the hydrodynamics and siltation of the fishing harbour project. Although model studies were previously carried out at the same project site by CWPRS in 2016, the HED proposed a revised layout considering the future expansion of the project. As a result, new modelling was conducted in 2024. The main objective of the modelling study was to evaluate the hydrodynamic and siltation changes after the proposed construction of fishing harbour and river training works. The analysis was based on bathymetric data of the area, tidal data, grain size data, suspended sediment concentration and river discharge collected in March 2023 from both the river region and offshore regions.

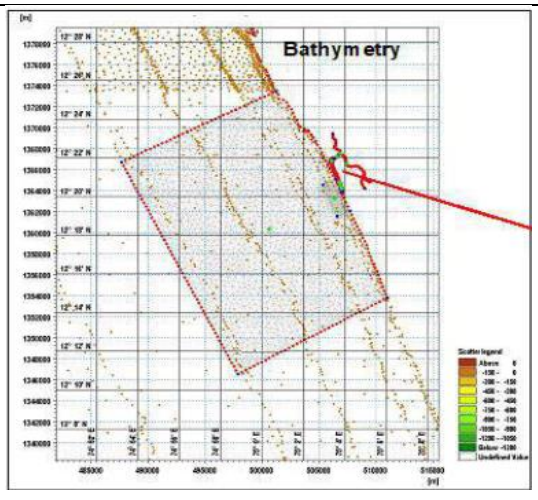
A two-dimensional hydrodynamic model MIKE-21 HD using Flexible Mesh, was used to study the hydrodynamics, while MIKE-21 MT module was used for sediment transport studies in both the existing and the proposed scenarios under prevailing tidal and wave conditions. The calibration of the model was done with the existing site conditions of the year 2023.

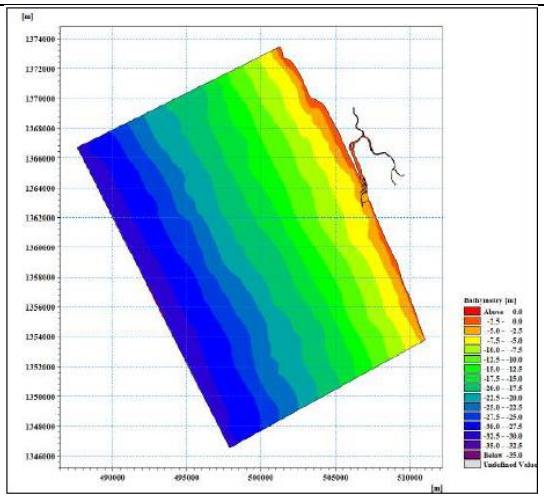
The key findings from the model studies include:

- Under the existing conditions, during monsoon season the Chithari River experiences increased water flow, which carries away sediments that had accumulated during the non-monsoon season. The estimated maximum deposition of about 0.1 m in a year over the computational domain is obtained. The annual sedimentation estimated at the river mouth is about 0.021 m.
- For the proposed conditions, there is a slight increase in deposition during the monsoon season at the river mouth and below the southern breakwater as compared to non-monsoon season. The annual sedimentation rate is estimated to be 0.03 m in the Fishing Harbour, 0.05 m near the north and south breakwaters of the proposed development, and 0.045 m at the river mouth. The increased sedimentation near the breakwaters is primarily caused by local water circulation patterns.

Compared to the existing conditions, there is a slight increase in sedimentation near the river mouth region for the proposed condition for the proposed scenario. This minor increase is attributed to decrease in currents resulting from dredging in the proposed area. Modelling studies indicate a decrease in current speeds across most of the study region for the proposed layout.

- The littoral drift at this study area under the existing condition was carried out by CWPRS in the year 2016. The study quantified the annual sediment transport along the coastline; the southward transport is observed to be of 0.531 Mm^3 and a northward transport to be 0.118 Mm^3. This results in a net southward transport of 0.413 Mm^3, indicating a significant movement of sediment towards the south.
- The proposed development is likely to influence the shoreline. Littoral drift is expected to cause accretion on the northern side and erosion on the southern side. The shoreline evolution after 10 years is predicted, the northern side is expected to experience accretion, extending 2,500 m along the coast and 68 m seaward and the southern side is projected to erode, with a potential loss of 1500 m along the coast and 40 m in cross-shore direction. It is observed that the shifting of the river mouth is about 200 m towards the north over a year.
- The bathymetric data for the offshore region and nearshore region was obtained from hydrographic charts provided by HED. Water level depth data over the estuary and river areas was obtained using the Acoustic Doppler Current Profiler (ADCP) of CWPRS. These water level measurements were subsequently utilized to estimate bathymetry before and after the construction of the breakwaters and the same is shown in Figure 7.2.





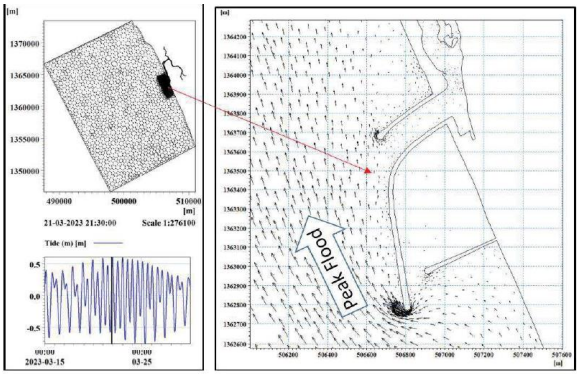
Bathymetry without the proposed layout	*Bathymetry with the proposed layout*

Source: Mathematical Model Studies to Assess Hydrodynamics and Siltation due to Construction of Fishing Harbour at Ajanur, Kerala, by CWPRS.

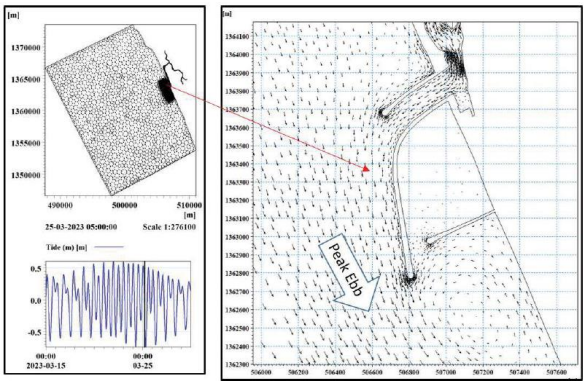
Figure 7.2: Bathymetry model for the project site

- During non-monsoon season, it is observed from the flow fields that circulation is formed near south breakwater during ebbing phase of tide. However, during monsoon season, circulation is formed near south breakwater (during flooding and ebbing phase of tide). In addition, during flooding phase, circulation is formed at 2 other locations near north breakwater and entrance of river mouth also.

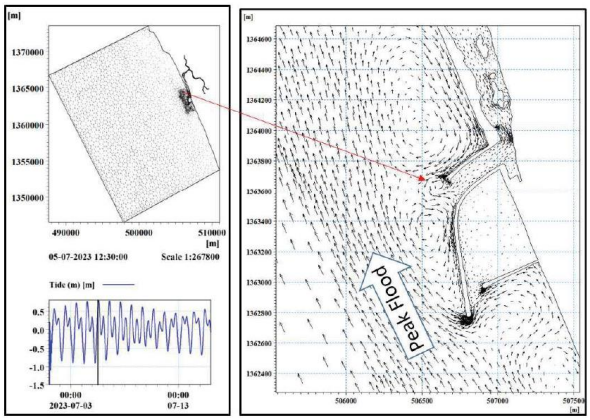
Though eddies formed around the circulation are weak, its intensity may change according to changes in local climate. Furthermore, four points t1, t2, t3 and t4 called as monitoring stations are considered for assessment of changes in currents after construction of proposed layout. The images showing the same are given in Figure 7.3.



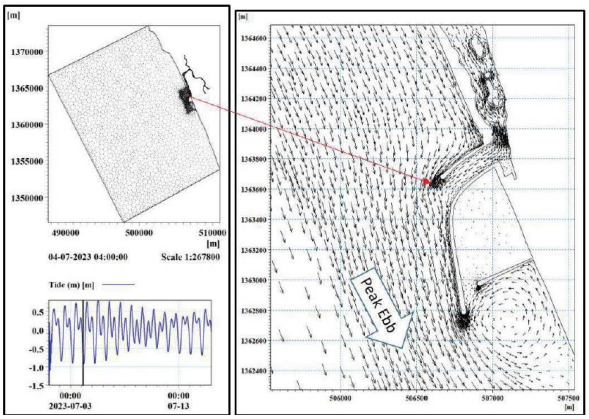
Flow field during peak flood - Non-monsoon



Flow field during peak ebb - Non-monsoon



Flow field during peak flood - Monsoon



Flow field during peak ebb - Monsoon

Source: CWPRS Modelling Report

Figure 7.3: Flow field for Proposed Condition

- There will be an increase in the magnitude of currents at the river mouth (T1) from 0.007 m/s to 0.1 m/s during the non-monsoon season and from 0.015 m/s to 0.3 m/s during the monsoon season. However, the magnitude of the current at the end of the river training breakwater (T2), at the harbour entrance (T3) and inside the harbour (T4) will significantly reduce after the proposed development. During the non-monsoon season, the peak modelled currents at T2, T3 and T4 for existing conditions are 0.43 m/s, 0.38 m/s, and 0.39 m/s respectively. After the proposed development the currents at these three monitoring stations will be reduced to 0.11 m/s, 0.06 m/s, and 0.008 m/s. During the monsoon season, the peak modelled currents at T2, T3 and T4 for existing conditions are 0.55 m/s, 0.46 m/s and 0.49 m/s respectively. After the proposed development, the currents at T2, T3 and T4 will be reduced to 0.21 m/s, 0.11 m/s, and 0.003 m/s respectively.

The capital dredging in the fishing harbour area, in the river mouth and along the river is calculated to be about 1.1 Mm^3.

Recommendation suggested by CWPRS after the modelling study are:

- The study suggests a proposed layout consisting of 1,150 m long north breakwater, 425 m long south breakwater and 435 m breakwater as a river training work near the mouth of Chithari river.
- If the shifting of the river mouth is significant even after the proposed development of the river training works then a seawall of appropriate length may be. Similarly, if the erosion on the south side of the proposed fishing harbour is progressive after the development, then a suitable shore protection measure in the form of a seawall or series of groynes may be provided.
- Maintenance dredging should be carried out near the river mouth and at the harbour entrance to maintain the desired depth for smooth movement of marine vessels.

Based on the model results, the proposed layout of the training works and the harbour basin, along with dredging activities, is found to be suitable for the prevailing conditions at the site.

7.5 Wave Flume Study

The desk and wave flume studies have been carried out by CWPRS, Pune to evolve the design cross-section of breakwater. For the design of the breakwater, a water level of 2.60 m was considered as the Design Water Level (DWL), which is 1.20 m above the Mean Higher High Water (i.e., Storm Surge of 0.80 m + Sea level rise of 0.40 m). The significant wave height of 4.0 m was considered for the design of breakwater. The key findings of the study include the following:

- The design of the breakwater includes tetrapod in the armour, a 7 m wide and 0.5 m thick crest slab, and a 0.5 m thick parapet wall with the end of the breakwater protected by a proper roundhead.
- The cross section of the trunk portion of breakwater is designed for bed levels of -2 m and -4.50 m, the sea-side armour consists of 2T tetrapod with a 1:2 slope, while the lee-side armour uses 0.5-1T stones with a 1:2 slope. The core is composed of 20-50 kg stones, and a 0.3 m thick bedding layer of 20 kg stones is provided. For the -4.5 m bed level, the sea-side armour utilizes 6T tetrapod with a 1:2 slope, and the lee-side armour employs 1-2T stones with a 1:2 slope. The core consists of 20-100 kg stones, and a 0.3 m thick bedding layer of 20 kg stones is used. All stones will have a density of 2.6 T/m^3. A 7m wide carriageway will be constructed on top of the breakwater.
- The roundhead portion of the breakwater, designed at -4.50 m bed level, features an 8.0T tetrapod armour layer on a 1:2 slope. This is supported by a 6 m wide toe berm composed of 3-4T stones. A clear carriageway of 8 m width is planned for this section.
- The construction may be phased to ensure safety and economy and temporary roundheads may be provided if work is curtailed.
- Regular surveys and maintenance are essential to identify and address any damage to the breakwater.

The hydraulic stability of the breakwater section was confirmed through wave flume studies, and the section was found to be safe from a hydraulic point of view. This design ensures the breakwater's ability to provide tranquil conditions in the harbour, protecting it from strong wave action while minimizing overtopping and structural damage.

7.6 Risk Assessment and Disaster Management Plan

Risk assessment is a methodology used to determine the nature and extend of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, livelihood, and the environment on which they depend. Risk management refers to the practices, policies, and procedures designed to minimize or eliminate the unacceptable risks.

7.6.1 Hazard Identification for the Project

Hazard identification is based on the likelihood of occurrence in a particular area. Kerala State Disaster Management Authority (KSDMA) has identified about 40 hazards likely to occur in the state, which include 17 natural hazards and 23 anthropogenic hazards as per Kerala State Disaster Management Plan (KSDMP) 2016.

To obtain more site-specific information, the hazards identified by the District Disaster Management Authority (DDMA) of Kasaragod District have also been referred from District Disaster Management Plan - 2015 (DDMP).

Based on KSDMP, 2016, and DDMP Kasaragod, 2015 the possible hazards likely to occur at the project site are identified and are classified into natural calamities (weather, geological, and biological) and anthropogenic activities. The possible hazards identified for the project site is given below:

a. Natural Calamities

The probability of occurrence of natural disasters at the site with respect to the maps available in DDMP Kasaragod for the corresponding natural disaster is detailed in Section 3.11 of Chapter 3 of this EIA report. The natural hazards identified to create risks at the project site are:

- Cyclone
- Lightning
- Earthquake
- Drought
- Flood
- Coastal hazards

Hazard seasonality mapping of Kasaragod District for the identified natural hazards is given in Table 7.2

Table 7.2: Hazard Seasonality Mapping of Kasaragod District

Type of Disaster	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cyclone				←	→							
Lightning				←	→				←	→		
Earthquake	←											→
Drought			←		→							
Flood						←		→				
Tsunami	←											→
Sea Erosion						←		→				

Type of Disaster	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Epidemics	←	—	—	—	—	—	—	—	—	—	—	→

Source: DDMP, Kasaragod - 2015

The possible hazards identified for the proposed project site are given below:

a. Anthropogenic Disasters

The anthropogenic hazards that may pose a risk to the proposed project can be categorized into hazards during the construction and operation phases. The major causes identified for the hazards during the construction phase of the harbour are given below:

- Oil & chemical spills
- Vessel Collisions
- Boat capsizing
- Accidental drowning
- Accidents at the construction site on the land like falling from heights, tripping, etc.

The major causes identified for the hazards during the operation phase due to the harbour activities are given below:

- Design deficiencies
- Damage to the structures
- Inadequate disposal of waste
- Overcrowding within the auction hall and its surroundings

7.6.2 Consequences Assessment

The risk consequence levels have been defined to quantify the assessed risk. These levels are given in Table 7.3, with consequences based on the severity of impact due to a hazard on people, the environment, and property.

Table 7.3: Risk Consequence Levels

Risk Levels	Consequences	Qualitative Description of Impact on		
		People	Environment	Property
1.	Insignificant (Manageable)	Event does not result in injury (no medical treatment required)	No damage	No damage
2.	Minor (Short term, manageable)	Reversible injury or illness	Minor impact of short duration or short-term damage	Minor damage
3.	Moderate (Medium term)	Irreversible disability or impairment to one or more persons	Short term damage resulting in complaints, localized impact	Moderate damage
4.	Major (Long term)	Severe injuries to one or more persons, single fatality	Significant impact locally and potential for off-site impacts	Major damage

Risk Levels	Consequences	Qualitative Description of Impact on		
		People	Environment	Property
5.	Catastrophic (Irreversible, permanent)	Multiple fatalities or irreversible injuries	Significant impacts to regional ecosystems and threatened species potential for widespread off-site impacts	Significant loss

7.6.3 Standard Risk Assessment Matrix

A standard risk assessment matrix for the proposed project has been developed based on the likelihood of the risk and its consequence levels. The Standard Risk Assessment Matrix is given in Table 7.4.

Table 7.4: Standard Risk Assessment Matrix

Risk Probability / Likelihood	Consequences				
	Catastrophic (Irreversible, permanent) (5)	Major (Long term) (4)	Moderate (Medium term) (3)	Minor (Short term, manageable) (2)	Insignificant (Manageable) (1)
Almost certain (5)	Extreme (25)	Extreme (20)	High (15)	Medium (10)	Medium (5)
Likely (4)	Extreme (20)	High (16)	High (12)	Medium (8)	Low (4)
Possible (3)	High (15)	High (12)	Medium (9)	Medium (6)	Low (3)
Unlikely (2)	Medium (10)	Medium (8)	Medium (6)	Low (4)	Low (2)
Rare (1)	Medium (5)	Low (4)	Low (3)	Low (2)	Low (1)

7.6.4 Project Specific Consequence Analysis and Risk Assessment

The site and project specific risk assessment matrix, representing the risks before the adoption of any mitigation measures, is depicted in Table 7.5.

Table 7.5: Project Specific Risk Assessment Matrix (without Mitigation Measures)

S. No.	Hazards	Likelihood	Consequences	Level of Risk (without mitigation)
Naturally Triggered / Weather Related Hazards				
1.	Cyclone	Possible (3)	Major (4)	High (12)
2.	Lightning	Possible (3)	Moderate (3)	Medium (9)
3.	Earthquake	Unlikely (2)	Moderate (3)	Medium (6)
4.	Drought	Possible (3)	Moderate (3)	Medium (9)
5.	Flood	Possible (3)	Moderate (3)	Medium (9)
6.	Coastal Hazard	Possible (3)	Major (4)	High (12)

S. No.	Hazards	Likelihood	Consequences	Level of Risk (without mitigation)
Anthropogenic / Technologically Triggered				
1.	Accidents during construction phase	Likely (4)	Major (4)	High (16)
2.	Accidents during operation phase	Possible (3)	Moderate (3)	Medium (9)

It is noted that among the natural hazards, cyclone, and coastal hazard present a high level of risk, while lightning, earthquake, drought and flood pose a medium level of risk. Regarding anthropogenic hazards, the risks anticipated from accidents occurring during the construction is assessed as high and for the operational phase is assessed as medium. This analysis restates the significance of adopting site and project specific mitigation measures for reducing the risks.

7.6.5 Mitigation Measures/ Facilities Proposed to Control Identified Risks

The project specific consequence analysis and risk assessment identified hazards with high or medium risk levels. The important aspects of preparedness for risk management and mitigation measures for each identified hazard are as follows:

Cyclone

- Technical assistance for early warning and hazard risk mitigation shall be obtained from DDMA Kasaragod.
- Emergency response team shall be activated immediately upon receiving timely warning from DDMA and adequate measures shall be taken when a warning for cyclone is issued to evacuate the workers.
- Construct harbor buildings, warehouses, and shelters using cyclone-resistant materials and design standards
- During cyclone warnings, all loose cargo, containers, and equipment should be secured or moved to safer storage areas to prevent them from becoming projectiles in high winds.

Lightning

- Provide lightning arrestors in the building at the landside facilities of the harbour.
- Regularly monitor weather forecasts and issue warnings when thunderstorm forecasts.
- Use audible or visual alarms in outdoor and exposed areas of a harbour to warn personnel of approaching lightning storms.
- Implement protocols to suspend operations during thunderstorms
- Establish designated lightning-safe shelters like fully enclosed buildings for workers.

Earthquake

- Emergency evacuation plan along with safety measures shall be implemented. All the information and instructions from concerned department and DDMA shall be scrupulously followed.
- Design and construct buildings and infrastructure to comply with national seismic building codes that account for earthquake forces.

Drought

- The project proposes to reduce its dependence on groundwater by harvesting and reuse of rainwater collected from the roof of buildings proposed in the harbour.
- Apart from this, measures shall be explored for the recharge of storm runoff into the groundwater.

Flood

- Synchronize the operation schedule with meteorological warnings to avoid work during heavy rain.
- Set up flood warning systems to alert harbour authorities, ship operators, and personnel, enabling them to take precautionary measures.
- Ensure that the harbour receives real-time data on weather conditions.
- Enhance storm water drainage systems to handle excess rainwater and prevent flooding within the harbour area. Ensure regular maintenance to keep drains and culverts clear of debris.
- Use flood-resistant materials for buildings and equipment near the waterfront.

Coastal Hazards

- Implement and maintain an early warning system for fishermen and harbour authorities to receive real-time alerts about tsunamis or high wave activities.
- Set up clear evacuation protocols and disseminate knowledge about safety measures during coastal emergencies.
- Restore natural sand dunes and plant mangroves or other salt-tolerant vegetation as natural buffers against storm surges and coastal erosion.

Accidents during construction phase of the project:

- Ensure safe storage and handling of oil and hazardous chemicals.
- Ensure emergency response equipment like protective gear, absorbents, neutralizing agents, and containment booms are readily available.
- Implement continuous monitoring of water and soil quality in and around the harbour to detect any signs of contamination early and take immediate corrective action.
- Ensure that all machinery operators receive thorough training on equipment use, safety procedures, and emergency protocols. Regular refresher courses should also be provided.
- Schedule construction activities to avoid the peak erosion periods, such as during the rainy season or high-wave conditions, to minimize the risk of erosion.
- Install temporary barriers or sandbags to protect construction sites and adjacent coastal areas from erosion caused by storms or high waves.
- Ensure boats are loaded safely and within capacity.
- Implement physical barriers or restricted access to dangerous water areas where drowning risks are high, such as construction sites or deep bodies of water.
- Develop and communicate a detailed emergency response plan for drowning incidents, including procedures for rescuing individuals, administering first aid, and contacting emergency services.

Accidents during operation phase of the project:

- Hazardous materials shall be stored in designated locations after obtaining necessary approvals.
- The leachable materials shall be stored in closed containers/leak proof packaging.
- Sufficient number of staff trained in first aid measures shall be deployed at the site at all times.
- Adequate number of first aid kits shall be provided.
- Fishers shall be encouraged to use adequate PPE & adequate safety measures shall be installed and regularly monitored.
- Skilled workers shall be chosen for operating the machineries.
- Develop and enforce traffic management plans to ensure the safe movement of vehicles and vessels within the harbour.
- Install and maintain clear and visible safety signs and warnings around the harbour to alert personnel and visitors to potential hazards and safety procedures.
- Establish and enforce standard operating procedures (SOPs) for all harbour operations, including emergency response to ensure consistency and safety.
- Continuously monitor weather conditions and implement protocols to suspend operations or take precautionary measures during adverse weather conditions, such as storms or high winds.
- Maintain reliable communication systems for coordination among personnel, ships, and emergency services. Use radios, alarms, and signalling devices to ensure effective communication.
- Conduct regular risk assessments to identify potential hazards and vulnerabilities in harbour operations. Use the findings to update safety protocols and mitigation measures.
- Implement measures to prevent environmental contamination, such as proper waste disposal, spill response systems, and monitoring of water quality to detect any potential pollution early.

7.6.6 Risk Assessment Matrix after Implementation of Mitigation Measures

The implementation of mitigation measures reduces the likelihood of occurrence of hazards. The impact of consequence can also be reduced by adopting suitable mitigation measures. Reduction of the likelihood of risk and level of consequences, reduces the overall level of risk, given in Table 7.6.

Table 7.6: Project Specific Risk Assessment Matrix (with Mitigation Measures)

S. No.	Hazards	Level of Risk (without mitigation)	Likelihood	Consequences	Level of Risk (with mitigation)
Naturally Triggered / Weather Related Hazards					
1.	Cyclone	High (12)	Possible (3)	Moderate (3)	Medium (9)
2.	Lightning	Medium (9)	Possible (3)	Minor (2)	Medium (6)
3.	Earthquake	Medium (6)	Unlikely (2)	Minor (2)	Low (4)
4.	Drought	Medium (9)	Possible (3)	Insignificant (1)	Low (3)
5.	Flood	Medium (9)	Possible (3)	Minor (2)	Medium (6)
6.	Coastal Hazard	High (12)	Possible (3)	Moderate (3)	Medium (9)
Anthropogenic / Technologically Triggered					

S. No.	Hazards	Level of Risk (without mitigation)	Likelihood	Consequences	Level of Risk (with mitigation)
1.	Accidents during construction phase	High (16)	Unlikely (2)	Minor (2)	Low (4)
2.	Accidents during operation phase	Medium (9)	Unlikely (2)	Minor (2)	Low (4)

It can be noted that the risk levels shall be reduced drastically by adopting suitable mitigation measures.

7.6.7 Emergency Preparedness Plan (EPP)

For the safe transition from normal operation to emergency operations and systematic shut down during the emergency, an Emergency Response Team with appropriate lines of authority with succession planning and actuating the response management at site has been identified. Objective of an Emergency Response Team are:

- To promptly control problems as they develop at the site.
- To prevent or limit the impact on other areas.
- To provide emergency personnel, selecting them for duties compatible with their normal work functions wherever feasible. The assigned roles and responsibilities should make full use of existing harbour services and organizations, including fire safety, health and medical services, transportation, personnel management, maintenance, and security, to ensure efficient coordination and an effective response during emergencies.
- Employees must assume additional responsibilities as per laid down procedure of DMP whenever an emergency alarm sounds.

Emergency Organization and Responsibility:

A structured approach with defined roles shall be designed to effectively manage and respond to the emergencies or disasters. An Organogram showing each component of Emergency Response Team for construction phase is shown in Figure 7.4.

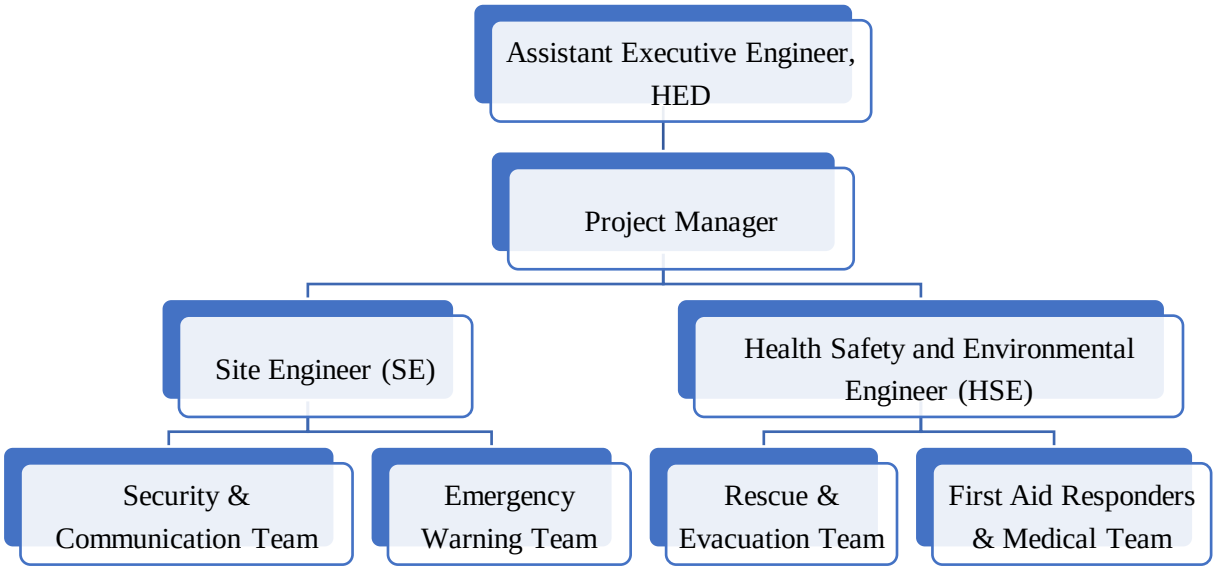


Figure 7.4: Organogram of Emergency Response Team for the Project

7.6.8 External Emergency Contact

The contact details of the concerned authorities in case of an emergency and the nearest fire stations/ police stations/hospitals etc. The details are given in Table 7.7. The distance to nearest police station, hospitals and fire & rescue station are given in Table 7.8. All these details shall be properly displayed at project site for easy access.

Table 7.7: External Emergency Contacts

S. No.	Official / Service	Telephone Number
1.	District Disaster Management Cell Collectorate, Kasaragod	0499 4257700
2.	Additional District Magistrate (ADM), Kasaragod	0499 4255833
3.	District Collector, Kasaragod	0499 4256400
4.	Municipal Corporation Secretary, Kanhangad	0467 2204530
5.	District Medical Officer (DMO), Kasaragod	9946105497
6.	District Hospital, Kanhangad	0467 2217019
7.	Primary Health Centre, Ajanur, Kanhangad	0467 2204985
8.	Manzoor Hospital, Kanhangad	0467 220 2070
9.	District Police Chief, Kasaragod	9497996972
10.	Hosdurg Police Station, Kanhangad	94979 80922
11.	Fire & Rescue Station, Kanhangad	0467 2202101
12.	KSEB Section Chithari Office, Kanhangad	0467 2267049

Table 7.8: Nearest Emergency Facilities

S. No.	Official / Service	Road Distance from Project Site (km)	Direction
Nearest Hospital			

S. No.	Official / Service	Road Distance from Project Site (km)	Direction
1.	Primary Health Centre, Ajanur, Kanhangad	1.60	SE of Southern breakwater
2.	Manzoor Hospital, Kanhangad	3.20	E of Southern breakwater
Nearest Police Station			
1.	Hosdurg Police Station, Kanhangad	5.00	SE of Southern breakwater
Nearest Fire Station			
1.	Fire and Rescue station, Kanhangad	5.00	SE of Southern breakwater

Chapter 8 Project Benefits

8.1 Improvement in the Physical Infrastructure

- A well-developed harbour, equipped with a basin, auction hall, wharf, adequate facilities for the fishers, etc. along with necessary infrastructural features such as access road, internal road, parking area, drainage facility, compound wall and side protection work will promote the overall growth of the fishing sector at the area.
- The construction of the northern and southern breakwater will provide a stable and tranquil location for the fishers to depart for fishing and bring back their catch.

8.2 Improvement in the Ecological Infrastructure

- The harbour will reduce the fishing vessel movement into the river channel and concentrate the same around the harbour, reducing the disturbance to the aquatic flora and fauna in the river channel.
- The harbour to be developed as a sustainable and eco-friendly harbour that's uses state-of-the-art smart technologies.
- RWH of capacity 50 kL is proposed within the harbour to ensure maximum harvesting of rainwater and its later use as freshwater at the facility.
- ETP of capacity 15 kLD is proposed for the treatment of 100% wastewater that will be generated from the landside facilities at the harbour. This will be minimizing harmful impact on ecosystems and public health that would have otherwise result from open disposal/ inadequate treatment of wastewater.
- The harbour will be fully powered by solar panels of capacity of 30 kW installed on-site.
- Green area of 3,000 m^2 is proposed with native trees and other plants at the harbour that will contribute to the local ecosystem and also enhance the aesthetics of the harbour.

8.3 Improvement in Social Infrastructure

- The improved auction hall will provide enhanced facilities and will smoothen operations in fish landing, processing, and auctioning, enabling a higher volume of catches to be processed and sold minimizing the wastage and also comfortable purchase facilities for the customers.
- Improved social infrastructure facilities for the fishers at the harbour such as toilets, rest sheds, canteen, etc. will ensure for fisher's welfare and comfort.
- Proposed construction of breakwaters will provide safe navigation facilities for the fishers, thereby protecting the life of fishers and their vessels.

8.4 Employment Potential

- Proposed construction of the harbour will provide employment opportunities for about 100 workers/day as direct employees and about 200 workers/ day as indirect employees during construction phase.
- During the operation phase of harbour 15 no. of staffs will be employed for the day-to-day operations in harbour.

- Proposed harbour will benefit 7,094 fishing population having 2,138 registered fishers spread over fishing villages from Hosdurg to Pallikkara in improving their quality and quantity of catches, and their enhancing their livelihood and economic stability.

8.5 Other Tangible Benefits

- Improved landside facilities will help in minimization of waste and enhancement of fish quality, thereby improve the marketing of catches.
- Safe landing facilities and calm harbour conditions will allow more fishing days, leading to higher income for fishers.
- Enhance the value of fish which will boost the revenue generated by fishing sector at the region.
- Development of the harbour to become a sustainable and tourism-oriented destination
- Beneficiary to the State revenue in the form of harbour fees, tariffs, and taxes.
- Enhance marine productivity and supports the goals of Pradhan Mantri Matsya Sampada Yojana (PMMSY)

In general, the proposed project will improve the socio-economic condition of the area.

Chapter 9 Environment Cost Benefit Analysis

Environmental cost benefit analysis is not required for the project as per the EIA Notification 2006 and hence not included in the EIA report

Chapter 10 Environment Management Plan

10.1 Environmental Policy

The HED, Government of Kerala shall develop the following Environmental Policy for the project:

- Develop and maintain a culture of Environmental stewardship.
- Implement proactive measures to prevent and control pollution, ensuring the protection of the local ecosystem. Safe and responsible disposal methods will be employed for any unavoidable waste.
- Provide adequate resources and personnel with the necessary training, skills, and knowledge to implement and uphold our environmental policies effectively.
- Establish and maintain systems and standard operating procedures to ensure compliance with all relevant environmental regulations and standards set by the Ministry of Environment Forest and Climate Change, as well as Government of Kerala and other local authorities.
- Actively communicate our environmental performance and progress to external stakeholders, including the local community and internal parties.

10.2 Implementation Arrangement for EMP

The implementation arrangement consists of the formation of the Environment Management Cell (EMC) and assigning roles and responsibilities to all members of the EMC for the prompt implementation of the EMP.

10.2.1. Environment Management Cell (EMC)

EMC shall be constituted as the institutional mechanism for ensuring the implementation of the EMP for the project.

10.2.1.1. Organogram of EMC

The organogram of EMC for the proposed fishing harbour is given in Figure 10.1.

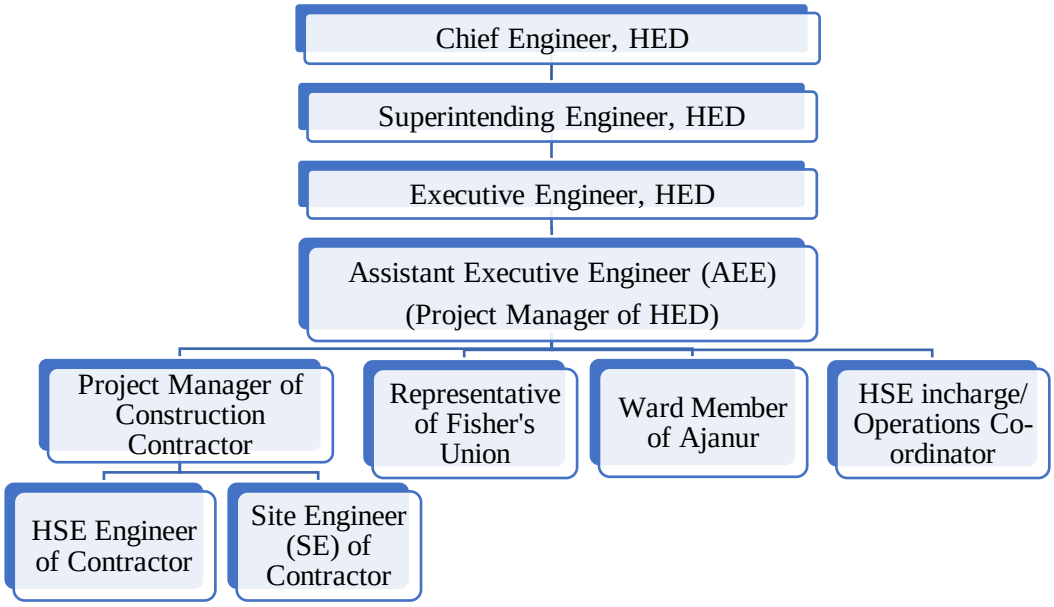


Figure 10.1: Structure of EMC for the Project

10.2.1.2. Flow of Information in EMC

During the construction phase, information from the field level shall be collected by the SE and HSE engineer of the construction contractor and shall report to their Project Manager. The Project Manager of the construction contractor shall report directly to the AEE of HED, who will also be the Project Manager of HED for this project. The AEE shall conduct inspections regarding the implementation of the EMP shall report to the Executive Engineer. During the operation phase, the representatives of the contractors will no longer be part of the EMC.

During the construction as well as the operation phase, the ground level implementation of the EMP shall also be overseen by the HSE in charge/ Operations Co-ordinator of the harbour, along with the representative of fisher's union and ward member of Ajanur. The presence of local ward member and representative of fisher's union in the EMC will ensure effective communication between the locals and fishers regarding their concerns and suggestions in the implementation of EMC. They shall report their updates to the AEE. The Executive Engineer shall be responsible for taking the field level decisions for the effective implementation of EMP. Executive Engineer shall report to the Superintending Engineer. Superintending Engineer will be responsible for evaluating the prompt functioning of the EMC and shall report the same to the Chief Engineer, who will be having the supreme charge of the project.

10.2.1.3. Role and Responsibilities of the EMC

1. Ensuring that all statutory environmental permits and clearances are obtained, and all conditions stipulated in these clearances/approvals are scrupulously followed.
2. Framing the site-specific Health Safety and Environment (HSE) guidelines, including awareness sessions on HSE guidelines in induction training programs, conducting refresher trainings on HSE guidelines, ensuring that, the HSE guidelines are being followed throughout the construction and operation phases of the project and updating the HSE guidelines as and when required.
3. Finalizing the EMP in the EIA report, including the cost estimates.
4. Ensuring the implementation of EMP through regular inspections at the site.
5. Conduct monthly meetings to evaluate the implementation of EMP and undertake corrective actions, if required.
6. Responsibilities must be assigned to relevant personnel for ensuring that the EMP documentation system is maintained, and that document control is ensured. Maintain the records of fund allocation of EMP activities and its progress and ensure the timely completion. Maintaining MoM of the meetings of the EMC, stakeholder engagements, grievance redressal meetings, etc.
7. Undertaking the EMoP through NABL accredited laboratory during the construction and operation phases.
8. Undertaking Environmental Compliance Audits once in a year for identification of non-compliances if any and suggesting corrective and preventive action.
9. Ensuring the employment opportunities for the local population in the construction phase
10. Maintaining the Grievance Redressal System and resolving any complaints from the construction workers/contractors, employees and local population
11. Maintaining an Environmental Issues Register, formulating necessary rectification measures for the issues based on the severity in consultation with relevant expert institutions.

12. Emergency/incident planning and review of the effectiveness of the same and adopting corrective actions, if any required. Communications with local bodies and District Administration for emergency preparedness.

10.3 Pollution and Waste Control Management Plan

10.3.1. Air and Noise Pollution Control Measures

The mitigation measures proposed to control the air pollution during construction phase includes transporting materials in covered vehicles, proper management of solid wastes to avoid burning of wastes, regular maintenance of machineries and vehicles, deploying vehicles with valid PUC for transportation of materials, providing barricades around the construction site etc.

To limit the spread of air pollutants from the construction areas to nearby populated areas, 3 m high barricades shall be erected around the construction site. The budget estimated for the same is INR 5,25,000 as capital cost and INR 55,000/ year as recurring cost.

Similarly, during operation phase, the mitigation measures proposed are proper maintenance of machineries and equipment and deploying vehicles with valid PUC for transport of materials and vehicle. Burning of garbage and waste shall not be permitted in the project site. The maintenance of the internal roads and parking areas shall be undertaken regularly to ensure these are in good conditions and the increase in vehicular movement of visitors to the harbour does not lead to unmanaged increase in fugitive emissions from the vehicular movement. For the maintenance of internal road and parking area, an amount of INR 2,75,000/ year shall be allocated as recurring cost.

Vehicle and equipment inspection camps shall be conducted yearly during the construction phase and operation phase. The budget estimated is a recurring cost of INR 1,00,000/ year during the construction phase and INR 50,000/ year during the operation phase, to ensure that the machinery and vehicles for the construction and operations conform to the prevailing noise regulations.

10.3.2. Wastewater Management Measures

Any spillage of fuel, oil or lubricants necessary for construction equipment/ machinery/ vehicles shall be stored at designated location with impervious floor to prevent spillage into land or water body. In-case of an accidental spillage onto the land/ water body, immediate spill containment measures shall be adopted. For this, spill containment kits which include absorbent pads, adsorbent socks, etc. shall be made available at the construction site.

10.3.2.1. Rainwater and Storm Water Management Plan

To conserve water, a RWH tanks of capacity 50 kL will be provided and the capital cost for the installation of RWH are considered in the project cost. The harvested rainwater shall be used to meet the fresh water requirement of the harbour. The RWH shall be regularly cleaned and filters shall be replenished at least twice a year, during the operation phase of the project.

For storm water management, a network of drain in the parking area will be provided for the disposal of storm water runoff into the river. These drains shall be laid during the beginning of constructions of landside facilities to effectively manage the stormwater runoff from the construction site. Along with drain a detention tank shall be provided for desilting the flow from the drains before it is let out into the

waterbody. During the operation phase, the storm water drains and the detention tank shall be regularly cleaned, especially before the onset of monsoon to avoid blockages.

10.3.2.2. Sewage Management Plan

Adequate sanitary facilities shall be provided for the construction workers by providing temporary toilets with portable STP for the management of wastewater from construction workers at site.

During operation phase ETP of capacity 15 kLD will be installed to manage the wastewater generated. The capital cost for the ETP is considered in the project cost. The Operation and Maintenance (O&M) of ETPs shall be properly carried out.

10.3.2.3. Budgetary Estimate for Wastewater Management

Budgetary estimate for wastewater management measures is given in Table 10.1.

Table 10.1: Budget estimate for Wastewater Management

S. No	Item	Capital Cost (in INR)	Recurring Cost per year (in INR)
Construction Phase			
1.	Oil spill containment kits (Including Absorbent Pads, Absorbent Socks, Disposable Bags, Safety Goggle etc.)	10,000	5,000
2.	Storm water management (a detention tank before disposal of water and seasonal desilting of this tank and the drains)	55,000	30,000
3.	Wastewater management of 100 workers by providing temporary toilets connected to portable STP	3,75,000	1,05,000
	Budgetary allocation for Construction Phase	**4,40,000**	***1,40,000***
Operation Phase			
1.	Maintenance of RWH tanks of capacity 50 kL	-	50,000
2.	Maintenance and seasonal desilting of the storm water drains and detention tank	-	25,000
3.	O&M cost for wastewater management for the harbour by using ETP of 15 kLD	-	2,10,000
	Budgetary allocation for Operation Phase	**-**	***2,85,000***

10.3.3. Solid Waste Management

For the management of waste at the site, efficient waste management system for sorting, recycling and reusing waste materials on-site shall be implemented. For the management of solid waste generated by 100 construction workers, 2 aerobic composting bins shall be provided. The non-biodegradable waste shall be collected in 'waste separation and collection bins' and shall be regularly handed over to authorised waste handlers. 2 sets of waste separation and collection bins shall be provided for collection of plastics, paper, cans & others. These bins may be relocated as per the progression of the work to the most easily accessible area for the construction workers at that particular period. For the efficient management of solid waste, an amount of INR 1,00,000 is estimated as capital cost and INR 40,000/year as recurring cost during the construction phase.

During operation phase, the waste generated at the fishing harbour by the operation workers and any other waste like fish waste, etc. shall be segregated at source to fish waste, biodegradables, plastics, and other waste. Fish waste shall be sold to recycle into fish meal. After construction phase, the bins used shall be reused at the landside facilities of the harbour during its operation phase. Any hazardous waste generated at the harbour shall be stored separately in closed areas on paved surfaces and the same shall be handed over to authorised hazardous waste handlers.

For the proper segregation of waste and its timely handing over, dedicated cleaning staff shall be appointed at the landside facilities. For solid waste management of operation phase, an amount of INR 60,000/year is estimated as recurring cost.

10.3.3.1. Concept of Waste Minimization

The project focusses on providing adequate auction hall and allied facilities at the harbour for the better post catch handling of the fishes. The harbour is proposed to be developed with smart technologies that will also help in efficient handling of the daily catch. This will increase the quality of the fishes for sale and ensure maximum sales of the catch, which will therefore minimize the wastage of fishes.

10.3.4. Clean Technology

Power requirement of the harbour during operation phase will be met from renewable energy sources. Solar panels of capacity 30 kW will be installed on the roof top of the suitable proposed structures. The budget for solar panel installation is estimated and is included in the project cost.

10.4 Natural Resource Conservation

10.4.1. Green Belt Development Plan

Green belt of 5 m width is proposed along the compound wall. The major purposes of greenbelt development are:

- Capture fugitive emissions, absorb pollutants and to aid in effective pollution control
- Retention of soil moisture and to prevent erosion
- Control spread of noise pollution beyond the project boundary
- Recharge of groundwater as well as to improve the microclimate
- Beneficial to preserve the biodiversity and thus preventing desertification of the area
- Enhance the aesthetics of the project site.

Species selected for green belt development is given in Table 10.2.

Table 10.2 Species selected for Green Belt

S. No.	Scientific Name	Local Name / Common Name	Family	Native / Exotic
1.	*Albizia lebbeck*	Vaga	Fabaceae	Native
2.	*Alstonia scholaris*	Ezhilamppala	Apocynaceae	Native
3.	*Artocarpus heterophyllus*	Chakka	Moraceae	Native
4.	*Azadirachta indica*	Ariyaveppu	Meliaceae	Native
5.	*Cocos nucifera*	Thengu	Arecaceae	Native

S. No.	Scientific Name	Local Name / Common Name	Family	Native / Exotic
6.	*Hibiscus tiliaceus*	Thaipparuthi	Malvaceae	Native
7.	*Mangifera indica*	Maavu	Anacardiaceae	Native
8.	*Moringa oleifera*	Muringai	Moringaceae	Native
9.	*Pongamia pinnata*	Pongam	Fabaceae	Native
10.	*Syzygium cumini*	Njaval	Myrtaceae	Native
11.	*Terminalia arjuna*	Nirmarutu	Combretaceae	Native
12.	*Thespesia populnea*	Poovaras	Malvaceae	Native

The budget for landscape development and green belt is included in the project cost. Apart from the capital cost, an amount shall be allocated for the maintenance of the green belt, yearly.

10.4.2. Conservation Plan for Schedule I species identified in the Study Area

Ptyas mucosa (Indian rat snake) and *Haliastur indus (Brahminy kite)* are the Schedule I species identified at the study area and the Conservation Plan for these species shall be prepared in consultation with concerned authorities.

10.4.3. Budgetary Allocation for Natural Resources Conservation

For the protection and conservation of the natural resources at the project site, the following training programs shall be undertaken:

- Construction workers shall be given awareness sessions for the implementation of EMP and for the conservation and protection of environment.
- During the operation phase, the fishers shall also be provided awareness training for using latest eco-friendly & most modern fishing measurers, etc.

The budgetary allocation for Natural Resources Conservation is detailed in Table 10.3.

Table 10.3: Budget estimate for Conservation Plan

S. No	Item	Capital Cost (in INR)	Recurring Cost per year (in INR)
Construction Phase			
1.	Ecological training for the workers on conservation and protection of the environment.	60,000	30,000
	Budgetary allocation for Construction Phase	***60,000***	***30,000***
Operation Phase			
1.	Maintenance of landscapes and green belt developed	-	1,10,000
2.	Awareness training for fishers on safety, environmental responsibilities, latest eco-friendly & most modern fishing measurers, etc.	-	45,000
	Budgetary allocation for Operation Phase	***-***	***1,55,000***

10.5 Occupational Health and Safety

It is the responsibility of the EMC for maintaining the Grievance Redressal System and resolving any complaints from the employees or fishers. The workers employed shall be provided with adequate basic amenities such as drinking water, sanitation facilities, PPE etc. An HSE engineer shall be appointed for daily inspection of sanitary and safety conditions at project site. Proper HSE trainings shall be provided at regular intervals for all the construction workers. Measures shall also be taken to minimise the risks to the workers such as fire hazards, accidents, etc. The budgetary estimate for ensuring occupational health and safety is given in Table 10.4.

Table 10.4: Budgetary Estimate for Occupational Health and Safety

S. No	Item	Capital Cost (in INR)	Recurring cost per year (in INR)
Construction Phase			
1.	Salary of HSE engineer for ensuring EMP is followed.	-	3,00,000
2.	Erection of warning sign boards: Near construction at the landside facilities, at material storage area, waste storage area, assembly area etc.	50,000	10,000
3.	HSE training for workers: 2-day induction training before start of construction and refresher training after 6 months.	30,000	15,000
4.	Appropriate PPE for 100 workers (helmet, jacket, shoes, life jacket, harness, googles, etc) and first aid facilities and water ambulance for workers.	5,15,000	80,000
5.	Medical check-up camps for 100 workers, once in 6 months	-	1,00,000
6.	Grievance redressal system for workers	-	40,000
Budgetary allocation for Construction Phase		***5,95,000***	***5,45,000***
Operation Phase			
1.	Pest control at the harbour premises, quarterly	-	45,000
2.	Medical checkup for the fishers and workers at the harbour.	-	2,00,000
3.	Grievance redressal system for harbour workers & fishers	-	50,000
Budgetary allocation for Operation Phase		***-***	***2,95,000***

10.6 EMP for Socio-Economic Environment

EMC shall maintain proper Grievance Redressal System. Half yearly meetings shall be conducted by the EMC both in construction as well as operation phase for resolving any complaints from the local population and the same shall be documented in the Grievance Redressal Register.

For ensuring that the construction activities do not cause inconvenience to the local public in terms of restrictions into the construction areas and other construction activities at the site, the people shall be

well informed of the construction and restriction on site through appropriate media (newspaper, radio) twice, at least 2 weeks prior to the start of the project. Soon after the completion of the constructions, the site shall be cleared of all construction debris, machinery, and the site shall be restored back. Traffic management measures such as providing clear instructions for traffic circulation by erecting sign boards and parking areas shall be provided to avoid congestion near the harbour due to the increased vehicular traffic to the harbour during the operational phase. The budgetary allocation for the same is given in Table 10.5.

Table 10.5: Budgetary Estimate for Socio-economic Environment

S. No	Monitoring Measure	Capital Cost (in INR)	Recurring Cost per year (in INR)
Construction Phase			
1.	Grievance redressal system for local population	-	40,000
2.	Informing people about construction & restriction on beach	15,000	-
3.	Erecting boards for traffic management within the harbour	35,000	-
4.	Site cleaning and restoration works	30,000	
	Budgetary allocation for Construction Phase	***80,000***	***40,000***
Operation Phase			
1.	Maintenance of traffic management boards in the harbour for regulating traffic	-	10,000
2.	Grievance redressal system for locals	-	50,000
	Budgetary allocation for Operation Phase	***-***	***60,000***

Corporate Environmental Responsibility (CER) is not applicable for the project as the proposed harbour does not attract EIA Notification 2006.

10.7 Monitoring for EMP

The measures to be taken to ensure that the mitigation measures are efficiently implemented and the budgetary allocation for the same is given in Table 10.6.

Table 10.6: Measures for Monitoring of EMP and its Budget

S. No	Monitoring Measure	Capital Cost (in INR)	Recurring Cost per year (in INR)
Construction Phase			
1.	Monthly meetings EMC and its necessary record keeping and inspections	-	35,000
2.	Environmental for monitoring quality of air, noise, soil, marine water, surface water, marine sediments.	-	2,46,000
	Budgetary allocation for Construction Phase	***-***	***2,81,000***
Operation Phase			
1.	Monthly meetings EMC and its necessary record	-	35,000

S. No	Monitoring Measure	Capital Cost (in INR)	Recurring Cost per year (in INR)
	keeping and inspections		
2.	Environmental for monitoring quality of air, noise, soil, marine water, surface water, marine sediments, inflow and outflow of ETP, DG set stack emission	-	2,85,000
3.	Shoreline Mapping	-	1,00,000
	Budgetary allocation for Operation Phase	**-**	***4,20,000***

10.8 EMP and Budgetary Provision for EMP

The EMP for the implementation of the proposed mitigation measures along with its implementation plan and budgetary allocation is depicted in Table 10.7. This includes the budget for implementation of the EMP in the construction and operation phases of the project. The efficient implementation of EMP for the construction phase shall be under the scope of the construction contractor and the implementation of EMP during the operation phase shall be under the scope of HED.

Table 10.7 Total Budget estimated for EMP

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
Construction Phase									
1.	Land	• Requirement of quarried granite stones. • Leakages of fuels, paints, etc. leading to contamination • Disposal of waste on land	High	• Purchase granite stones from quarry having valid EC. • Store fuels, paints, etc. on paved surfaces. • Management of C&D waste. • Solid and hazardous waste management	1,00,000	40,000	HSE and Site Engineer of Contractor	Construction period	Monthly
2.	Water	• Turbidity during dredging • Water requirement for construction • Withdrawal of groundwater	High	• Continuous monitoring turbidity levels • No withdrawal of groundwater from	4,40,000	1,40,000	HSE and Site Engineer of Contractor	Construction period	Daily

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
		• Wastewater generation by workers • Disposal of wastewater • Leakage of fuels/oils • Surface runoff from construction site		CRZ or wastage of water. • Purchased water via tankers for emergency. • Portable STP for wastewater management. • Refueling on paved designated surfaces. • Use oil spill containment kits in case of spills. • Cleaning and maintenance of drains, seasonally. • Detention tank before storm water disposal.					
3.	Air	• Unloading/ handling of construction material.	Moderate	• Dust barricade around constructions in landside facilities. • Vehicles with PUC	5,25,000	55,000	HSE and Site Engineer of Contractor	Construction period	Yearly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
		• Storage of construction material areas • Vehicular movement • Burning of garbage		• Covered vehicles for material transport. • No open burning					
4.	Noise & Vibration	• Loading/ unloading of materials • Operating machines/ equipment. • Movement of vehicles. • Construction activities like drilling, carpentry, etc.	Moderate	• Regular maintenance and lubrications of machines/ equipment • Equipment and vehicular inspection camp	-	1,00,000	HSE and Site Engineer of Contractor	Construction period	Yearly
5.	Ecology & Biodiversity	• Seepage of pollutants/ waste into land/ water affecting flora & fauna. • Construction on refugee space of crabs, fishes.	Moderate	• Ecological awareness training to workers	60,000	30,000	Site Engineer and HSE of Contractor	Construction period	Half yearly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
6.	Occupational Health and safety	• Unavailability of necessary facilities • Accidents at site • Poor working conditions	Moderate	• Provision for drinking water, toilets, etc. • Safety boards at site. • HSE engineer at site always • HSE training for workers • PPE for workers • First aid facilities • Medical check up • Grievance redressal for workers	5,95,000	5,45,000	HSE Engineer of Contractor	Construction period	Half yearly
7.	Socio-economic	• Restrictions into construction area of beach. • Inconvenience to the locals from construction activities and pollution. • Increased construction vehicular movement	Moderate	• Inform public prior to constructions • Grievance redressal for locals. • Erecting traffic management boards • Site restoration	80,000	40,000	HSE Engineer of Contractor and Ward members	Construction period	Half yearly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
8.	Climate	• Operations of various construction equipment/ machinery/ vehicles	Moderate	• Use of fuel-efficient equipment/ machineries • Trip scheduling of vehicles	-	-	Site Engineer of Contractor	Construction period	Half yearly
9.	General Measures	• Non-implementing of EMP	High	• EMC meeting • EMoP, half yearly	-	2,81,000	EMC	Construction period	Monthly
Budget for EMP of Construction Phase					***18,00,000***	***12,31,000***			
Operation Phase									
1.	Land	• Disposal of untreated solid waste • Spillage/ leakage of oil, diesel etc.	Moderate	• Solid waste management and handing over of waste to authorized handlers.	-	60,000	Operations coordinator	Life of Harbour	Monthly
2.	Water	• Freshwater requirement • Withdrawal of groundwater • Wastewater generation • Disposal of waste into water	Moderate	• O&M of RWH tank (50 kL) • No withdrawal of groundwater • O&M of ETP of capacity 15 kLD • No disposal of untreated wastewater	-	2,85,000	Operations coordinator	Life of Harbour	Monthly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
		• Runoff from landside facilitates • Spillage from boats & fuel storages.		• De-siltation and maintenance of drains with detention tank, Seasonally					
3.	Air	• Emissions from increased movement of vehicles to the harbour. • Emissions from machinery	Low	• Maintenance of internal roads and parking areas • Allow only vehicles with PUC.	-	2,75,000	Operations coordinator	Life of Harbour	Yearly
4.	Noise & Vibration	• Movement of fishing vessels and trucks • Operation of equipment.	Low	• Vehicle & equipment inspection camps	-	50,000	Operations coordinator	Life of Harbour	Yearly
5.	Ecology & Biodiversity	• Ecological habitat and species degradation due to increased boat movement, change in natural flow pattern • Unsuitable/ invasive species in green belt.	Moderate	• Training for fishers on environmental protection • Finalization of species for green belt in consultation with locals.	-	1,55,000	HSE in-charge of Harbour	Life of Harbour	Half yearly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
		• Lack of maintenance of green belt & landscape.		• Maintenance of green belt and landscape.					
6.	Occupational Health and safety	• Unsanitary conditions and water logging • Pest menace • Accidents in sea while fishing • Unsatisfactory working conditions for the harbour staff.	Moderate	• Maintenance of harbour premises. • Pest control quarterly • Instruct fishers on PPE and first aid • Medical checkup for fishers, half yearly • Mandate for insurance, yearly • Grievance redressal for harbour staff and fishers	-	2,95,000	HSE in-charge of Harbour and Representative of Fisher's Union	Life of Harbour	Daily
7.	Socio-economic	• Rush & competition due to influx of customers • Traffic congestion • Disturbance and inconvenience to locals.	Moderate	• Evaluate adequacy of harbour facilities • Traffic management boards • Grievance redressal system for locals, Quarterly	-	60,000	Operations coordinator and ward member	Life of Harbour	Yearly

S. No.	Components	Potential Sources of Impact/ Pollution	Magnitude of Pollution	Control Measures	Budget		Responsibility	Timeframe	Monitoring
					Capital Cost In INR	Recurring Cost/ year in INR			
8.	Climate Change	• Power requirement	Low	• Solar panels	-	-	Operations coordinator	Life of Harbour	Yearly
9.	General Measures	• Non-implementing of EMP	High	• EMC meeting & inspections • EMoP, half yearly • Shoreline mapping, yearly	-	4,20,000	EMC	Life of Harbour	Monthly
Budget for EMP for Operation Phase					**-**	***16,00,000***			

Chapter 11 Summary & Conclusions

11.1 Project Description

The proposed project involves constructing a fishing harbour at Ajanur, Kasaragod Taluk, Kasaragod District, Kerala, near the mouth of the Chithari River, with a fish landing capacity of 28,695 TPA. Currently, the site has a deteriorated fish landing centre with inadequate facilities such as a damaged auction hall, net mending shed, and toilet block. Additionally, the river mouth is highly migratory, frequently shifting, blocked due to sand bar formations during summer and causing significant damage to existing fishers, their properties and the infrastructure of the fish landing centre.

The inadequate facilities and migratory nature of river mouth pose significant risks to fishers and limit the potential of Ajanur's coast. To address these issues, HED proposes northern and southern breakwaters with a river training wall, which will stabilize the river mouth, prevent its closure during summer, reduce flash flood risk, protect coastal and upstream communities and provide calm basin for landing of boats. The project also includes landside facilities for the harbour such as a wharf, auction hall, berthing wharf, and essential amenities such as rest rooms, toilets, etc. for fishers and harbour visitors, waste management measures, facilities for ensuring security at the harbour. The harbour is proposed with latest smart technologies to aid in efficient handling of the catch with minimum wastage and maximum returns.

11.2 Description of Environment

Baseline monitoring was done for environment and social parameters during the study period (19.12.2022 to 14.03.2023) through reconnaissance survey followed by field visits, sample collection, stakeholder consultations & door-to-door household surveys.

The core zone (2 km radius) is dominated by water bodies. Ambient air quality is within prescribed limits for NAAQS) - 2009. Noise levels are within limits specified by Noise Pollution (Regulation and Control) Rules, 2000. The surface water monitored had minimal suspended particles and agreeable odour, but high levels of hardness, chloride, dissolved solids and sulphates, due to its proximity to the sea. Marine water quality is generally good, with optimal pH levels, low concentrations of harmful bacteria, and adequate dissolved oxygen to support marine life. Presence of phytoplankton, zooplankton, and benthic organisms were recorded at various sampling stations. Marine sediment quality is generally good, with low organic matter and heavy metals such as lead, mercury and cadmium below detectable limits and iron, manganese, zinc and copper in moderate level.

The local climate is tropical with hot summers and monsoons. The biodiversity assessment found a variety of plant life, including Schedule I species - *Ptyas mucosa* (Rat Snake) and *Haliastur indus* (Brahminy Kite), within the 10.0 km study area. No endangered animals were observed in the proposed quarry site. During consultation meeting with local elected representatives, they showed strong community support for the project as it is essential for enhancing safety and preventing boat accidents, and improve the livelihoods of the underprivileged fishing community in Kasaragod. Key suggestions included adding more rescue boats and personnel, and constructing sea walls to address coastal erosion. During door-to-door surveys, residents reported that the issue of saltwater intrusion have forced

residents to depend exclusively on pipeline water for their water needs and the region faces recurring threats of flooding and sea encroachment.

11.3 Anticipated Environmental Impacts and Mitigation Measures

Potential environmental impacts include air and noise pollution from construction and operation activities, erosion of land, marine water contamination, wastewater generation etc. Mitigation measures like erection of dust barriers around proposed harbour facilities, regular maintenance of machineries and vehicles, proper management of storm water and waste materials, proper storage of hazardous materials etc. shall be implemented to reduce the impacts during construction phase. Regular monitoring of land erosion and deposition patterns by continuous shoreline mapping by HED, implementation of coastal management strategies, provision of ETP of capacity 15 kLD and RHW tank of capacity 50 kL, proper traffic management plan, installation of solar panels of capacity 30 kW etc. will be implemented as mitigation measures for operation phase.

11.4 Environmental Monitoring Program

EMoP has been prepared to monitor the environmental quality during construction phase as well as during operation phase and shall be carried out through a NABL accredited laboratory. The parameters to be monitored are ambient air (3 no.s), noise level (3 no.s), surface water (1 no.s), soil (1 nos.), marine water (2 no.s), marine sediment (2 no.s), inlet and outlet water from ETP and stack emission from DG set. The EMoP budget estimated for construction phase is INR 2.46 Lakhs/year and for operation phase is INR 2.85 Lakhs/year.

11.5 Additional Studies

11.5.1. Public Hearing

This project does not require public hearing as it does not come under the purview of EIA notification 2006.

11.5.2. HTL/ LTL Demarcation

National Centre for Earth Science Studies (NCESS), Thiruvananthapuram has prepared the CRZ Status Report and the HTL/LTL map in 1:4000 scale superimposing the project layout. As per the CRZ mapping, the project site falls under CRZ IA, CRZ IB, CRZ II, CRZ-IVA, and CRZ-IVB Proposed construction of compound wall of 16.48 m falls within CRZ IA. HED decided not to proceed with the construction of compound wall within CRZ IA.

11.5.3. Mathematical Modelling Studies

The mathematical modelling studies conducted by CWPRS to identify the best suited layout of the breakwaters or the harbour and the river training works with respect to impact on hydrodynamics, siltation, wave propagation, and shoreline changes. The studies used various models to analyse different aspects of the project, including littoral drift, wave propagation, hydrodynamics, and sediment transport. The recommended layout is expected to improve conditions at the river mouth and provide a tranquil harbour basin, making it more suitable for fishing vessels.

11.5.4. Wave Flume Study

The wave flume studies conducted by CWPRS determined the optimal cross-sections for the trunk and rounded portions of the breakwaters. The design of the breakwater includes tetrapod in the armour, a 7 m wide and 0.5 m thick crest slab, and a 0.5m thick parapet wall with the end of the breakwater protected by a proper roundhead. The hydraulic stability of the breakwater section was confirmed through wave flume studies, ensuring its safety from a hydraulic point of view.

11.5.5. Risk Assessment and Disaster Management Plan

The project faces risk from natural hazards like cyclone, lightning, earthquake, drought, flood and costal hazard, as well as anthropogenic risks. Mitigation measures were proposed to reduce these hazards' impact. An Emergency Response Team shall be established, and contact details for relevant authorities and nearby facilities identified shall be prominently displayed at the harbour. These measures aim to ensure a seamless transition from normal operations to emergencies.

11.6 Project Benefits

- Constructing northern and southern breakwaters with a river training wall will stabilize the river mouth, prevent its closure during summer, reduce flash flood risk, protect coastal and upstream communities and provide calm basin for landing of boats.
- Provide enhanced infrastructure that meets the growing demands of fishing community, ensures hygienic standards and promote sustainable fishing practices in line with Food and Agriculture Organization (FAO) guidelines.
- Boost to local economy by enabling continuous fishing activity for over 300 days annually
- Improved working and living conditions for 7,094 coastal residents, including 2,138 registered fishers, through minimized risks of property damage and loss of life due to unpredictable river mouth shifts
- Employment opportunities for 100 workers per day during construction phase and 15 permanent staff and indirect employment through allied services like transport, maintenance and fish marketing during operation phase
- Enhance marine productivity and supports the goals of Pradhan Mantri Matsya Sampada Yojana (PMMSY)
- Cost-Benefit ratio is estimated to be 1.37

11.7 Environment Management Plan and Recommendations

The EMP for the project outlines a comprehensive approach to environmental protection and mitigation. HED will implement an environmental policy that emphasizes sustainability, pollution prevention, and community engagement.

To ensure effective implementation of EMP, an EMC will be formed with clear roles and responsibilities. The EMP addresses potential impacts and their mitigation measures. The EMP also includes budgetary allocations for various activities to ensure adequate resources for implementation.

Based on the EIA studies and other surveys conducted for the proposed project it can be concluded that the potential adverse environmental impacts can be mitigated to an acceptable level by adequate

implementation of the environment management measures. The recommendations for further mitigating the impacts of the project are:

- Continuously track the river mouth's movement and channel depth. If significant river mouth shifting occurs, even after project completion, then mitigation strategies recommended by the CWPRS (construction of seawall) shall be under taken.
- Measure the erosion rate at the southern side and if the erosion rate is found more than the prediction of CWPRS then the mitigation measures suggested by CWPRS shall be followed.

Chapter 12 Disclosure of Consultants

12.1 Introduction

This EIA report has been prepared by the environmental consulting firm, ULTRA TECH (Environmental Consultancy and Laboratory), on behalf of the HED of Government of Kerala. The report also incorporates relevant inputs from the project proponent.

ULTRA TECH, is a leading EIA consulting organization providing economically viable and feasible environmental solutions for sustainable development of new projects in 13 NABET accredited sectors. NABET accreditation certificate is attached as Annexure 2.

The company has network of operations as follows:

12.2 Address of Offices & Contact Details

The address and contact details of the head and branch offices are given in Table 12.1.

Table 12.1: Details of the Head & Branch Offices

Office Location	Address	Contact Details
Head Office, Thane	Unit No.: 206, 224-225, Jai Commercial Complex, Eastern Express Highway, Opp.: Cadbury, Thane West – 400 601, Maharashtra State, India	Ms. Rekha Margam +91 8149500506 Ms. Dipti Rathod +91 8692900073
Branch Office, Pune	C-1, 202, Saudamini Commercial Complex, Bhusari colony, Paud Road, Kothrud Pune – 411038, Maharashtra -India	Mr. Vikrant Kulkarni +91 9004666814
Branch Office, Kochi	Door no. 54/3858, 2nd floor, Chakkanat Building, Fatima Church Road, Elamkulam, Kadavanthra P.O., Ernakulam, Kerala - 682020	Ms. Ananthitha. A +91 9895200526
Branch Office, Kolkata	BD-009, 1st Ave Rd, BD Block, Sector 1, Salt Lake, Bidhannagar, Kolkata, West Bengal 700064	Mr. Debasish Sengupta +91 9674488198
Branch Office, Gandhinagar	Plot No. 305/2, Nr. GH-1, Sector-3, New Gandhinagar, Gujarat 382006	Mr. Roshan +91 9558117469

12.3 Brief Resume and Nature of Consultancy

The company is known for its specialization in offering a comprehensive suite of services related to environmental consulting, environmental laboratory testing, engineering for Effluent Treatment Plants (ETP), Sewage Treatment Plants (STP), Water Treatment Plants (WTP), project consultancy, as well as the operation and maintenance of ETP and STP Plants, with a dedicated team of over 250 environmental professionals. ULTRA TECH is in its commitment to delivering high-quality environmental services and has earned a reputation for its expertise in the field.

ULTRA TECH provides services in the following environmental domain; Environmental Impact Assessment, Social Impact Assessment, Environment Management Plan, Quantitative Risk Assessment, Disaster Management Plan, Rehabilitation and Resettlement, Coastal Regulatory Zone Clearances, Forest Clearance, Wild Life Clearance, No Objection Certificates for CFE, CFO and Renewals, Environmental Due Diligence, Social Due Diligence, Environmental Audit, Social Audit, Ecological Due Diligence, Environmental Legal Advisory Services, Environmental Status Reports.

ULTRA TECH's commitment to delivering high-quality environmental services and its extensive expertise in various sectors make it a valuable partner for projects seeking environmental clearances and sustainable development

ULTRA TECH has its own state of the art NABL certified and MoEF& CC approved Laboratory and providing environmental baseline as well as compliance monitoring. The laboratory monitors and analyses various environmental parameters, including air quality, water quality, soil quality, groundwater quality, surface water quality, noise levels, and meteorological data etc.

ULTRA TECH has completed several thousand assignments in environmental consultancy and clearance for large building construction and area development projects apart from infrastructure, industrial and related projects sectors. The ULTRA TECH laboratory is serving as the backbone of all the core business services and ETP-STP-WTP projects department has been providing engineering and project management consultancy on turnkey basis handling O & M of several hundred plants in Mumbai and suburban areas.

12.4 EIA Team Member

The work presented in this report was carried out by ULTRA TECH. The names of the team members associated with the preparation and studies of EIA/EMP other than those mentioned in Part A of Annexure VII are given in Table 12.2.

Table 12.2: Details of the Team Members

Name of Internal Team Member	Activity/Area	Involvement	Under Approved Expert
		Actual Work Performed	
Ms. Ananthitha A	Quality Check & Project Coordinator	Project planning, team framing, work distribution, review of EIA report; guidance in modification of contents.	EIA Coordinator
Mr. Vishudath	Quality Check & Review	Guidance in modification of contents.	EIA Coordinator
Ms. Thushara Sudheish K	Team lead and EIA report writing – project details and EMP	Coordination for data collection, data analysis, coordination with FAEs and team members; compiling the primary & secondary	EIA Coordinator

Name of Internal Team Member	Activity/Area	Involvement	Under Approved Expert
		Actual Work Performed	
Ms. Farsana Nazrin V. B.	EIA Report writing - Ecology and Biodiversity	project data for EIA report; EIA/EMP report preparation by conducting site visit.	FAE - EB
Ms. Gayathri MN	EIA Report writing - project details and EMP	Coordination with FAEs and team members; compiling the primary & secondary data for EIA report; EIA/EMP report preparation	EIA Coordinator
Ms. Ambily U S	EIA Report writing - Land Use		FAE - LU
Ms. Shahana Younus	Assisting in EIA Report writing	Assisting in EIA/EMP report preparation, data analysis, coordination with FAEs and team members.	FAE - WP
Ms. Anju Mathew	Assisting in EIA Report writing		FAE - AP
Ms. Malavika S	Assisting in EIA Report writing		FAE - SW

12.5 Laboratory Information

The details of the laboratory for baseline environmental monitoring are given in in Table 12.3. NABL certificate of the laboratory is attached as Annexure 3.

Table 12.3: Details of Laboratory

Name of Laboratory	NABL Certificate No.	Address	Contact Infromation
M/s. Envirodesigns Eco Labs	Certificate No. TC-7114 valid till 18.10.2025	Eco Tower, Janatha Jn., Palarivattom, Kochi, Kerala, India	Dr. K. L. Antony + 91 9388609505 lab@envirodesigns.in

Annexure 1: Environmental Baseline Monitoring Reports

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Recognised Lab by Ministry of Environment, Forests & Climate Change (Govt. of India) as per E (P) Act 1986

TC-7114

NOISE LEVEL MONITORING REPORT

Report No. : EEL/LR/23/0021743/686
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location : Kanhangad
Monitoring done by: Lab field technicians

Sample Particulars: Ambient Noise Level Monitoring

Source of monitoring : Ambient Noise Level Monitoring (24 Hrs)
Sampling method : Monitoring Protocol No. EEL/ENV/MP/01
Method Used: IS 9989:1981

Location Code	ANQ1	ANQ2	ANQ3
Date of Monitoring	09.03.23 – 10.03.23	10.03.23 – 11.03.23	10.03.23 – 11.03.23
Time of Monitoring	09.00AM –09.00AM	09.00AM –09.00AM	09.00AM –09.00AM
Location of Monitoring	Near Indian Oil Chithari Fuel	Near Iqbal HSS , Kanhangad	Next to proposed project site
Location coordinates	N 12^0 21' 35.56'' E 75^0 3' 53.20''	N 12^0 19' 50.37'' E 75^0 4' 41.77''	N 12^0 20' 10.03'' E 75^0 3' 54.57''
Lab Identification Code	N/03/684	N/03/685	N/03/686
Sample receipt form Ref. No. with date	SRF/N/03/684 dt.13.03.23	SRF/N/03/685 dt.13.03.23	SRF/N/03/686 dt.13.03.23

Presentation of Results

Location Code	Location of Monitoring	Value Reported in dB (A) L_{eq}	
		Day time	Night time
ANQ1	Near Indian Oil Chithari Fuel	49.8	40.4
ANQ2	Near Iqbal HSS , Kanhangad	48.1	37.3
ANQ3	Next to proposed project site	42.5	35.6

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TC-7114

NOISE LEVEL MONITORING REPORT

Report No. : EEL/LR/23/0021743/686

Presentation of Results

Sl. No.	Hourly Interval (hrs)	Hourly L_{eq} Values		
		ANQ1	ANQ2	ANQ3
1.	09:00-10:00	50.3	51.2	45.3
2.	10:00-11:00	51.8	50.3	46.3
3.	11:00-12:00	50.3	49.3	48.3
4.	12:00-13:00	51.6	49.8	47.6
5.	13:00-14:00	52.3	50.3	45.8
6.	14:00-15:00	50.8	48.6	44.3
7.	15:00-16:00	50.2	49.7	40.8
8.	16:00-17:00	52.3	51.2	41.7
9.	17:00-18:00	55.6	50.3	40.8
10.	18:00-19:00	50.7	47.6	40.2
11.	19:00-20:00	49.6	48.3	39.8
12.	20:00-21:00	48.3	44.6	38.2
13.	21:00-22:00	48.1	40.3	38.7
14.	22:00-23:00	46.3	39.6	36.8
15.	23:00-00:00	43.2	37.8	35.4
16.	00:00-01:00	40.1	35.1	33.2
17.	01:00-02:00	38.3	34.9	33.6
18.	02:00-03:00	35.6	35.8	34.6
19.	03:00-04:00	35.8	36.3	35.3
20.	04:00-05:00	36.1	36.8	35.8
21.	05:00-06:00	39.7	39.2	37.1
22.	06:00-07:00	42.3	40.1	38.2
23.	07:00-08:00	44.8	42.3	39.1
24.	08:00-09:00	46.7	48.3	40.6

LIMIT AS PER NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000				
	Industrial Area	Commercial Area	Residential Area	Silence Zone
Day Time	75	65	55	50
Night Time	70	55	45	40

Note: Day time means - 6.00 AM to 10.00 PM Night time means - 10.00 PM to 6.00 AM

Instruments used for Monitoring

1. Sound Level Meter, Make: Cygnet, Model: A0106-302, ID No. : EEL/SLM/01
2. Sound Level Meter, Make: Cygnet, Model: 2511, ID No. : EEL/SLM/02

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

....End of Report.....

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TEST REPORT

Report No. : EEL/LR/23/0021736/679
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/679 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Soil sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 kg x 1
Packaging details: Plastic cover
Location coordinates : 12°20'10.06" N 75° 3'54.92" E
Tests required: For the parameters listed below;

Lab identification code: SO/03/679
Analysis completion date: March 20, 2023
Description of sample by the customer: Soil 1(S1)
(Location- Fishing Landing Centre, Ajanoor)

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH	--	IS 10158: 1982	6.6
2.	Conductivity	µS/cm	IS 14767 : 2000	282
3.	Water Holding Capacity	%	Indian Bureau of Mines Analysis of Soil: 2012	52
4.	Organic Matter	%	IS 2720 (Pt 22): 1972	0.23
5.	Sulphur	mg/kg	IS 14685: 1999	207.75
6.	Total Phosphorus	mg/kg	USEPA 3052 : 1996	23.35
7.	Sodium	mg/kg	USEPA 3052 : 1996	159.72
8.	Potassium	mg/kg	USEPA 3052 : 1996	208.54
9.	Particle Size distribution (Dry weight basis)	%	SOP No. EEL/WP/SO/09	
	a) Above 2.36 mm			12.34
	b) 2.36-1.18 mm			13.28
	c) 1.18 mm-600 microns			14.03
	d) 600-425 microns			11.53
	e) 425-300 microns			18.20
	f) 300-150 microns			19.48
	g) 150-75 microns			6.22
	h) Below 75 microns			4.92

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

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Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/679 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Soil sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 kg x 1
Packaging details: Plastic cover
Location coordinates : 12°20'10.06" N 75° 3'54.92" E
Tests required: For the parameters listed below;

Lab identification code: SO/03/679
Analysis completion date: March 20, 2023
Description of sample by the customer: Soil sample(S1)
(Location- Fishing Landing Centre, Ajanoor)

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	Chloride (Water extractable)	mg/kg	SOP No. EEL/WP/SO/04	242.18
2.	Total Kjeldhal Nitrogen	%	IS 10158: 1982	771.57
3.	Phosphate	mg/kg	USEPA 3052 : 1996	55.60

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-25

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TEST REPORT

Report No. : EEL/LR/23/0021737/680
Issue Date : March 22, 2023

Issued To:
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Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/680 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/680
Analysis completion date: March 20, 2023
Description of sample by the customer: Surface water 1 (SW1) [Chithari River]
Location coordinates : 12°21' 58.5" N 75°3 '30.06" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH at 25^{0}C	---	Cl.2 of IS 3025 (Pt 11):1983	7.5
2.	Colour	Hazen Units	Cl. 2 of IS 3025 (Pt 4):2021	4.0
3.	Odour	---	IS 3025 (Pt 5): 2018	Agreeable
4.	Turbidity	NTU	IS 3025 (Pt 10):1984	0.80
5.	Total Hardness as $CaCO_3$	mg/l	Cl. 5 of IS 3025 (Pt 21):2009	8160
6.	Iron as Fe	mg/l	Cl. 6 of IS 3025 (Pt 53):2003	0.22
7.	Chloride as Cl	mg/l	Cl. 2 of IS 3025(Pt 32):1988	18345.38
8.	Fluoride as F	mg/l	Cl. 5 of IS 3025(Pt 60):2008	BDL(MDL-0.2)
9.	Total Dissolved Solids	mg/l	IS 3025(Pt 16):1984	38090
10.	Sulphate as SO_4	mg/l	Cl. 4 of IS 3025(Pt 24):1986	3324.38
11.	Total Alkalinity as $CaCO_3$	mg/l	Cl. 8.1 of IS 3025(Pt 23):1986	133.25
12.	Nitrate as NO_3	mg/l	Cl. 3 of IS 3025(Pt 34):1988	1.42

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

Sl. No.	Parameters	Method	Result
1.	E.coli or thermotolerant coliform bacteria, MPN/100ml	IS 1622 : 1981	<2
2.	Total coliform bacteria, MPN /100ml	IS 1622 : 1981	<2

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

....End of Report.....

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS *KOCHI-25*

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Approved 'A' grade Lab by Kerala State Pollution Control Board

TEST REPORT

Report No. : EEL/LR/23/0121737/680
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/680 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/680
Analysis completion date: March 20, 2023
Description of sample by the customer: Surface water 1 (SW1) [Chithari River]
Location coordinates : 12°21' 58.5" N 75°3 '30.06" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Method	Result
1.	Phytoplankton, cells/ml	IS 1622 : 1981	40
2.	Zooplankton, cells/ml	APHA 10200	20

....End of Report.....

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-23

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TEST REPORT

Report No. : EEL/LR/23/0021732/675
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/675 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/675
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine water 1 (MW1) [Muttumthala Beach]
Location coordinates : 12°20' 16.65" N 75°3 '46.00" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH at 25^{0}C	---	Cl.2 of IS 3025 (Pt 11):1983	7.4
2.	Colour	Hazen Units	Cl. 2 of IS 3025 (Pt 4):2021	4.0
3.	Odour	---	IS 3025 (Pt 5): 2018	Agreeable
4.	Turbidity	NTU	IS 3025 (Pt 10):1984	3.80
5.	Total Hardness as $CaCO_3$	mg/l	Cl. 5 of IS 3025 (Pt 21):2009	7140
6.	Iron as Fe	mg/l	Cl. 6 of IS 3025 (Pt 53):2003	0.46
7.	Chloride as Cl	mg/l	Cl. 2 of IS 3025(Pt 32):1988	19568.40
8.	Fluoride as F	mg/l	Cl. 5 of IS 3025(Pt 60):2008	BDL(MDL-0.2)
9.	Total Dissolved Solids	mg/l	IS 3025(Pt 16):1984	38286
10.	Sulphate as SO_4	mg/l	Cl. 4 of IS 3025(Pt 24):1986	2030.02
11.	Total Alkalinity as $CaCO_3$	mg/l	Cl. 8.1 of IS 3025(Pt 23):1986	102.50
12.	Nitrate as NO_3	mg/l	Cl. 3 of IS 3025(Pt 34):1988	0.31
13.	Conductivity	µS/cm	IS 3025 (Pt 14):2013	63810
14.	Calcium as Ca	mg/l	Cl. 5 of IS 3025(Pt 40):1991	490.58
15.	Magnesium as Mg	mg/l	Cl. 6 of IS 3025(Pt 46):1994	1440.55
16.	Sodium as Na	mg/l	IS 3025 (Pt 2) : 2019	10698.14
17.	Potassium as K	mg/l	IS 3025 (Pt 2) : 2019	58.62

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

ENVIRODESIGNS ECO LABS KOCHI-25

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TC-7114

Report No. : EEL/LR/23/0021732/675

Sl. No.	Parameters	Unit	Method	Result
18.	Mercury as Hg	mg/l	Cl. 5 of IS 3025 (Pt 48):1994	BDL(MDL-0.0005)
19.	Lead as Pb	mg/l	IS 3025(Pt 2):2019	BDL(MDL-0.005)
20.	Copper as Cu	mg/l	IS 3025 (Pt 2) : 2019	BDL(MDL-0.01)
21.	Zinc as Zn	mg/l	IS 3025(Pt 2):2019	0.08
22.	Cadmium as Cd	mg/l	IS 3025(Pt 2):2019	BDL(MDL-0.001)
23.	Total Suspended Solids	mg/l	IS 3025 (Pt 17): 1984	16
24.	Biochemical Oxygen Demand @ 27°C for 3 days	mg/l	IS 3025(Pt 44):1993	3.20
25.	Chemical Oxygen Demand	mg/l	IS 3025(Pt 58): 2006	156
26.	Dissolved Oxygen	mg/l	Cl. 4.1 & 4.2 of IS 3025 (Pt 38) :1989	5.60
27.	Oil & Grease	mg/l	Cl. 5 of IS 3025(Pt 39): 2021	BDL(MDL-0.05)
28.	Salinity	mg/l	USEPA 842-B-06- 003: 2006	32264.40
29.	Temperature	^{0}C	USEPA 170.1: 1974	31
30.	Phosphate as PO_4	mg/l	Cl. 4 of IS 3025 (Pt 31):1988	0.49

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

Sl. No.	Parameters	Method	Result
1.	E.coli or thermotolerant coliform bacteria, MPN/100ml	IS 1622 : 1981	<2
2.	Faecal coliforms, MPN /100ml	IS 1622 : 1981	<2

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-25

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Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/675 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/675
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine water 1 (MW1) [Muttumthala Beach]
Location coordinates : 12°20' 16.65" N 75°3 '46.00" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Method	Result
1.	Phytoplankton, cells/ml	IS 1622 : 1981	80
2.	Zooplankton, cells/ml	APHA 10200	40

....End of Report.....

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
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ENVIRODESIGNS ECO LABS *KOCHI-25*

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TEST REPORT

Report No. : EEL/LR/23/0021733/676
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/676 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/676
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine water 2 (MW2) [Ajanoor Beach]
Location coordinates : 12°19' 53.43" N 75°3 '58.21" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH at 25^{0}C	---	Cl.2 of IS 3025 (Pt 11):1983	7.4
2.	Colour	Hazen Units	Cl. 2 of IS 3025 (Pt 4):2021	4.0
3.	Odour	---	IS 3025 (Pt 5): 2018	Agreeable
4.	Turbidity	NTU	IS 3025 (Pt 10):1984	6.90
5.	Total Hardness as $CaCO_3$	mg/l	Cl. 5 of IS 3025 (Pt 21):2009	8670
6.	Iron as Fe	mg/l	Cl. 6 of IS 3025 (Pt 53):2003	0.16
7.	Chloride as Cl	mg/l	Cl. 2 of IS 3025(Pt 32):1988	18345.38
8.	Fluoride as F	mg/l	Cl. 5 of IS 3025(Pt 60):2008	BDL(MDL-0.2)
9.	Total Dissolved Solids	mg/l	IS 3025(Pt 16):1984	37380
10.	Sulphate as SO_4	mg/l	Cl. 4 of IS 3025(Pt 24):1986	2402.50
11.	Total Alkalinity as $CaCO_3$	mg/l	Cl. 8.1 of IS 3025(Pt 23):1986	102.50
12.	Nitrate as NO_3	mg/l	Cl. 3 of IS 3025(Pt 34):1988	0.49
13.	Conductivity	µS/cm	IS 3025 (Pt 14):2013	62300
14.	Calcium as Ca	mg/l	Cl. 5 of IS 3025(Pt 40):1991	613.22
15.	Magnesium as Mg	mg/l	Cl. 6 of IS 3025(Pt 46):1994	1738.59
16.	Sodium as Na	mg/l	IS 3025 (Pt 2) : 2019	10012.50
17.	Potassium as K	mg/l	IS 3025 (Pt 2) : 2019	64.26

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

ENVIRODESIGNS ECO LABS KOCHI-25

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TC-7114

Report No. : EEL/LR/23/0021733/676

Sl. No.	Parameters	Unit	Method	Result
18.	Mercury as Hg	mg/l	Cl. 5 of IS 3025 (Pt 48):1994	BDL(MDL-0.0005)
19.	Lead as Pb	mg/l	IS 3025(Pt 2):2019	BDL(MDL-0.005)
20.	Copper as Cu	mg/l	IS 3025 (Pt 2) : 2019	BDL(MDL-0.01)
21.	Zinc as Zn	mg/l	IS 3025(Pt 2):2019	BDL(MDL-0.01)
22.	Cadmium as Cd	mg/l	IS 3025(Pt 2):2019	BDL(MDL-0.001)
23.	Total Suspended Solids	mg/l	IS 3025 (Pt 17): 1984	22
24.	Biochemical Oxygen Demand @ 27°C for 3 days	mg/l	IS 3025(Pt 44):1993	3.10
25.	Chemical Oxygen Demand	mg/l	IS 3025(Pt 58): 2006	144
26.	Dissolved Oxygen	mg/l	Cl. 4.1 & 4.2 of IS 3025 (Pt 38) :1989	5.60
27.	Oil & Grease	mg/l	Cl. 5 of IS 3025(Pt 39): 2021	BDL(MDL-0.05)
28.	Salinity	mg/l	USEPA 842-B-06- 003: 2006	30247.88
29.	Temperature	^{0}C	USEPA 170.1: 1974	31
30.	Phosphate as PO_4	mg/l	Cl. 4 of IS 3025 (Pt 31):1988	0.28

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

Sl. No.	Parameters	Method	Result
1.	E.coli or thermotolerant coliform bacteria, MPN/100ml	IS 1622 : 1981	<2
2.	Faecal coliforms, MPN /100ml	IS 1622 : 1981	<2

….End of Report…..

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-25

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TEST REPORT

Report No. : EEL/LR/23/0121733/676
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/W/03/676 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Water sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 L x 2
Packaging details: Pet bottle
Lab identification code: W/03/676
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine water 2 (MW2) [Ajanoor Beach]
Location coordinates : 12°19' 53.43" N 75°3 '58.21" E
Tests required: For the parameters listed below,

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Method	Result
1.	Phytoplankton, cells/ml	IS 1622 : 1981	160
2.	Zooplankton, cells/ml	APHA 10200	80

....End of Report.....

Jesty M. T
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS *KOCHI-25*

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TEST REPORT

Report No. : EEL/LR/23/0021734/677
Issue Date : March 22, 2023

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Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/677 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Sediment sample

Sample receiving date : March 10, 2023
Lab identification code: SO/03/677
Analysis starting date : March 10, 2023
Analysis completion date: March 20, 2023
Quantity of sample received: 1 kg x 1
Description of sample by the customer: Marine Sediment 1(MS1) [Muttumthala Beach]
Packaging details: Plastic cover
Location coordinates : 12°20' 16.65" N 75°3 '46.00" E
Tests required: For the parameters listed below;

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH	--	IS 10158: 1982	7.2
2.	Texture - Sand	%	SOP No. EEL/WP/SO/08	45
3.	Texture - Silt	%	SOP No. EEL/WP/SO/08	7.0
4.	Texture - Clay	%	SOP No. EEL/WP/SO/08	48
5.	Organic Matter	%	IS 2720 (Pt 22): 1972	0.03
6.	Total Phosphorus	mg/kg	USEPA 3052 : 1996	58.42
7.	Aluminium	mg/kg	USEPA 3052 : 1996	2.02
8.	Iron	mg/kg	USEPA 3052 : 1996	1007.51
9.	Lead	mg/kg	USEPA 3052 : 1996	BDL(MDL-1.0)
10.	Manganese	mg/kg	USEPA 3052 : 1996	1.05
11.	Zinc	mg/kg	USEPA 3052 : 1996	2.03
12.	Copper	mg/kg	USEPA 3052 : 1996	1.78
13.	Mercury	mg/kg	USEPA 3052 : 1996	BDL(MDL-0.05)
14.	Cadmium	mg/kg	USEPA 3052 : 1996	BDL(MDL-1.0)

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-25

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TEST REPORT

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Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/677 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Sediment sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 kg x 1
Packaging details: Plastic cover
Lab identification code: SO/03/677
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine Sediment 1(MS1) [Muttumthala Beach]
Location coordinates : 12°20' 16.65" N 75°3 '46.00" E
Tests required: For the parameters listed below;

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	Total Kjeldhal Nitrogen	%	IS 10158: 1982	97.63

Sl. No.	Parameters	Method	Result
1.	Benthos per sample	APHA 10500	15

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS * KOCHI-25 *

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TEST REPORT

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Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/678 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Sediment sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 kg x 1
Packaging details: Plastic cover
Lab identification code: SO/03/678
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine Sediment 2 (MS2) [Ajanoor Beach]
Location coordinates : 12°19' 53.43" N 75°3 '58.21" E
Tests required: For the parameters listed below;

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	pH	--	IS 10158: 1982	7.3
2.	Texture - Sand	%	SOP No. EEL/WP/SO/08	41
3.	Texture - Silt	%	SOP No. EEL/WP/SO/08	7.0
4.	Texture - Clay	%	SOP No. EEL/WP/SO/08	52
5.	Organic Matter	%	IS 2720 (Pt 22): 1972	0.042
6.	Total Phosphorus	mg/kg	USEPA 3052 : 1996	48.49
7.	Aluminium	mg/kg	USEPA 3052 : 1996	1.54
8.	Iron	mg/kg	USEPA 3052 : 1996	1042.31
9.	Lead	mg/kg	USEPA 3052 : 1996	BDL(MDL-1.0)
10.	Manganese	mg/kg	USEPA 3052 : 1996	1.34
11.	Zinc	mg/kg	USEPA 3052 : 1996	3.29
12.	Copper	mg/kg	USEPA 3052 : 1996	2.57
13.	Mercury	mg/kg	USEPA 3052 : 1996	BDL(MDL-0.05)
14.	Cadmium	mg/kg	USEPA 3052 : 1996	BDL(MDL-1.0)

Note:- BDL: Below Detection Limit MDL: Minimum Detection Limit

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

ENVIRODESIGNS ECO LABS KOCHI-25

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ECO LABS
(Food Quality / Water / Environmental Testing Lab)
In pursuit of quality
ISO 9001: 2015, ISO 45001: 2018 Certified organisation
Recognised Lab by Ministry of Environment, Forests & Climate Change (Govt. of India) as per E (P) Act 1986
Approved 'A' grade Lab by Kerala State Pollution Control Board

TEST REPORT

Report No. : EEL/LR/23/0021735/678
Issue Date : March 22, 2023

Issued To:
M/s. ULTRA TECH
Environmental Consultancy and Laboratory
No.199, First Floor, Door No. 55/1308- B
Girinagar, Near Community Hall, Club Road
Kadavanthra, Kochi-682020.

Customer ref. : Email dt. 03.02.2023
Project: - Construction of Ajanoor Fishing Harbour, Kasargod
Proposed Project Location: Kanhangad
Sample receipt form Ref. No. : SRF/SO/03/678 dt. 10.03.2023
Sampling done by: Customer

Sample Particulars: Sediment sample

Sample receiving date : March 10, 2023
Analysis starting date : March 10, 2023
Quantity of sample received: 1 kg x 1
Packaging details: Plastic cover
Lab identification code: SO/03/678
Analysis completion date: March 20, 2023
Description of sample by the customer: Marine Sediment 2 (MS2) [Ajanoor Beach]
Location coordinates : 12°19' 53.43" N 75°3 '58.21" E
Tests required: For the parameters listed below;

SAMPLE TESTED AS RECEIVED

Sl. No.	Parameters	Unit	Method	Result
1.	Total Kjeldhal Nitrogen	%	IS 10158: 1982	101.02

Sl. No.	Parameters	Method	Result
1.	Benthos per sample	APHA 10500	13

....End of Report.....

Susan Abraham
Technical Manager
Authorised Signatory
Envirodesigns Eco Labs

Jesty M. T.
Dy.Tech. Manager-Microbiology
Authorised Signatory
Envirodesigns Eco Labs

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Annexure 2: NABET Accreditation Certificate

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QUALITY COUNCIL® OF INDIA
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NABET

National Accreditation Board for Education and Training

Certificate of Accreditation

ULTRA TECH, Thane

206, 224-225, Jai Commercial Complex, Eastern Express Highway, Opp. Cadbury, Khopat, Thane- 400601

*The organization is accredited as **Category-A** under the QCI-NABET **Scheme for Accreditation of EIA Consultant Organization, Version 3**: for preparing EIA/EMP reports in the following Sectors*

S. No	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1.	Mining of minerals including opencast / underground mining	1	1 (a) (i)	A
2.	River Valley projects	3	1 (c)	A
3.	Thermal power plants	4	1 (d)	B
4.	Metallurgical industries (ferrous & non-ferrous)	8	3 (a)	A
5.	Cement plants	9	3 (b)	A
6.	Synthetic organic chemicals industry	21	5 (f)	A
7.	Distilleries	22	5 (g)	A
8.	Oil & gas transportation pipeline (crude and refinery/ petrochemical products), passing through national parks/ sanctuaries/coral reefs / ecologically sensitive areas including LNG terminal	27	6 (a)	A
9.	Ports, harbours, break waters and dredging	33	7 (e)	A
10.	Highways,	34	7 (f)	A
11.	Common Effluent Treatment Plants (CETPs)	36	7 (h)	B
12.	Building and construction projects	38	8 (a)	B
13.	Townships and Area development projects	39	8 (b)	B

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in RAAC minutes dated February 18, 2025 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no QCI/NABET/ENV/ACO/25/3541 dated March 10, 2025. The accreditation needs to be renewed before the expiry date by ULTRA TECH, Thane following due process of assessment.

Valid up to
October 18, 2027

Issue Date
March 10, 2025

Certificate No.
NABET/EIA/24-27/RA 0378

Varinder Kanwar
Prof (Dr) Varinder S Kanwar
CEO - NABET

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET website.

Annexure 3: NABL Accreditation Certificate of the Laboratory

National Accreditation Board for Testing and Calibration Laboratories

CERTIFICATE OF ACCREDITATION

ENVIRODESIGNS ECO LABS

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

ECO TOWER, JANATHA JN., PALARIVATTOM, KOCHI, KERALA, INDIA

in the field of

TESTING

Certificate Number: TC-7114

Issue Date: 19/10/2023 **Valid Until:** 18/10/2025

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Entity: ENVIRODESIGNS ECO LABS

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

Risk Assessment and Disaster Management Plan

for

Proposed Construction of Ajanur Fishing Harbour

at

Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State
Fish Landing Capacity: 28,695 Tonnes Per Annum
[Schedule as per EIA Notification: Not applicable
Category: Standalone CRZ Clearance]

by

Harbour Engineering Department
Government of Kerala
Harbour Engineering Kasaragod Division,
Office of the Executive Engineer,
Clock Tower Junction, Near Railway Station, Kasaragod, Kerala – 671121

Prepared by

(Environmental Consultancy and Laboratory)
Unit No. 206, 224, 225 Jai Commercial Complex,
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Email: kochi@ultratech.in, Tel: 022 – 25342776/25360198, 0484 4301947
NABET Certificate No.: NABET/EIA/24-27/RA0378; Valid till 18.10.2027

Document No: UTC/PRJ/DMP/00216/2024/01/01

Field Study Period: November 2024

September 2025

Revision History						
S. No.	**Document Reference No.**	**Issue No.**	**Revision No.**	**Revision Date**	**Brief Description of the Revision**	**Reason for Revision/ Amendment**
1.	UTC/PRJ/DMP/00216/2024	01	00	29.11.2024	-	Draft
2.		01	01	19.09.2025	-	Internal Review

Disclaimer:

This RA&DMP report has been prepared with all reasonable skills, knowledge, care and diligence by NABET accredited EIA Consultant, ULTRA TECH, in accordance with the terms of the contract (Agreement No. 13/2022-23/EE/HED/KGD dated 12/07/2022) with Harbour Engineering Department, Government of Kerala, the project proponent, incorporating General Terms and Conditions of Contract and taking in to account of the resources devoted to it, for the submission to Kerala Coastal Zone Management Authority, for consideration for CRZ clearance. The report was discussed with project proponent, in detail before releasing.

This RA&DMP report has been prepared using information received from project proponent, collecting primary data and compilation of secondary data from available resources. ULTRA TECH is not responsible for the origin and authenticity of the information provided by proponent. Neither this report nor any of its contents can be used for any purpose other than stated above, without the prior written consent from the project proponent.

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Abbreviations

Abbreviation	:	Description
BMTPC	:	Building Materials and Technology Promotion Council
CRZ	:	Coastal Regulation Zone
DDMA	:	District Disaster Management Authority
DDMP	:	District Disaster Management Plan
KSDMA	:	Kerala State Disaster Management Authority
NABET	:	National Accreditation Board for Education and Training
PPE	:	Personal Protective Equipment
PWD	:	Public Works Department
RA&DMP	:	Risk Assessment & Disaster Management Plan
SDMP	:	State Disaster Management Plan

Chapter 1. Introduction

1.1 Purpose of the Report

The Harbour Engineering Department (HED) proposes the construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala. The fishing harbour is designed to have a fish landing capacity of 28,695 Tonnes Per Annum (TPA). The project attracts the Coastal Regulation Zone (CRZ) Notification 2019, as it falls in CRZ IA, CRZ IB, CRZ II, CRZ IVA and CRZ IVB and hence Risk Assessment and Disaster Management Plan (RA&DMP) is to be prepared to identify the risks from any potential hazards that may affect the safety of the users and the property and to outline the mitigation measures and management plan to prepare for, respond to and recover from the potential hazards. ULTRA TECH has been entrusted by HED to prepare the RA&DMP for submission to the Kerala Coastal Zone Management Authority (KCZMA) to obtain CRZ clearance.

1.2 Identification of the Project and the Project Proponent

The project is proposed by HED to address the issues faced by the local fishing community and the fishery industry in the region, which operates near the Chithari River. Fishers at Ajanur currently face challenges in their day-to-day fishing activities due to the migratory nature and periodic closing of the Chithari River mouth, and inadequate fish handling facilities at the existing Fish Landing Centre (FLC). Existing FLC includes only a dilapidated auction hall, net mending shed and toilet block. The master plan for the project involves the following features:

- North and south breakwaters for establishing the harbour basin and river training wall.
- Landside facilities of the harbour which include wharf, auction hall, berthing wharf, canteen, net mending shed, shop rooms, locker rooms, gate and gate house, office cum surveillance room, Rain Water Harvesting, Effluent Treatment Plant (ETP), etc.
- For the stabilization of the river mouth, a river training wall on the north side of the river mouth, dredging and reclamation is proposed in accordance with the modelling studies conducted by Central Water & Power Research Station (CWPRS), Pune.

The details of the project are given in Table 1.1.

Table 1.1: Details of the Project

Particulars	Descriptions
Name of the Project	Proposed construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala.
Name and Address of the Correspondent	Office of the Executive Engineer, Harbour Engineering Kasaragod Division, Clock Tower Junction, Near Railway Station, Kasaragod, Kerala – 671 121 E-mail ID: eekgd.hed@kerala.gov.in
Village & Panchayath	Ajanur
Taluk & District	Kasaragod
State	Kerala
Proposed features	• Northern breakwater of length 1,150 m

<table>
<tr><th>Particulars</th><th>Descriptions</th></tr>
<tr><td></td><td>

Southern breakwater of length 425 m
River training work of Chithari river in the form of a breakwater of length 435 m
Reclamation bund of length 400 m
Wharf of dimension 120 m × 6.6 m
Auction hall of dimension 60 m × 15 m
Dredging proposed in between the north breakwater and river training work at the mouth of Chithari river
2-story building including canteen, rest shed, locker room, gear shed
Other buildings such as toilet block, workshop building, office room cum harbour surveillance camera room.
ETP, RWH facility landscaping and green belt
Mechanical conveyor system & Automation
Electrification and Installation of Solar energy system
Gate and Gate House with ATM and toll booth.
Water supply arrangements in the harbour with overhead tank and sump
Construction of wharf for berthing facility
Navigational aid, pressure washer and cleaning equipment,
Development of green area, approach road, internal road, parking area, drainage facility, compound wall and side protection work
Development of smart infrastructure and automated systems

</td></tr>
<tr><td>CRZ Zone*</td><td>
<table>
<tr><th>CRZ Zone</th><th>Length (m)</th><th>Area (m^2)</th></tr>
<tr><td>CRZ IA</td><td>16.48</td><td>-</td></tr>
<tr><td>CRZ IB</td><td>187.68</td><td>11,181.91</td></tr>
<tr><td>CRZ II</td><td>719.08</td><td>3,636.97</td></tr>
<tr><td>CRZ IVA</td><td>749.14</td><td>44,911.33</td></tr>
<tr><td>CRZ IVB</td><td>-</td><td>94.60</td></tr>
<tr><td>Total</td><td>1,672.38</td><td>59,824.81</td></tr>
</table>
</td></tr>
<tr><td>Fish landing capacity</td><td>28,695 TPA</td></tr>
<tr><td>Project cost</td><td>INR 20,000 Lakhs</td></tr>
<tr><td>Construction period</td><td>46 months</td></tr>
</table>

Source: DPR

**As per the CRZ report and map prepared by NCESS, Thiruvananthapuram*

The project site falls within CRZ IA, CRZ IB, CRZ II, CRZ IVA and CRZ IVB, based on the CRZ map prepared by National Centre for Earth Science Studies (NCESS), Thiruvananthapuram in May 2025 and therefore requires CRZ clearance from KCZMA in accordance with CRZ Notification 2019.

1.3 Project Location

Geo-coordinates of the project location are; northern breakwater - 12°20'11.66"N, 75°3'53.04"E, southern breakwater - 12°19'55.64"N, 75°3'58.95"E, river training works: 12°20'17.39"N, 75°3'51.34"E and harbor

facilities: 12°20'10.18"N, 75°3'54.87"E, at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala State.

The index map showing the project site is given in Figure 1.1.

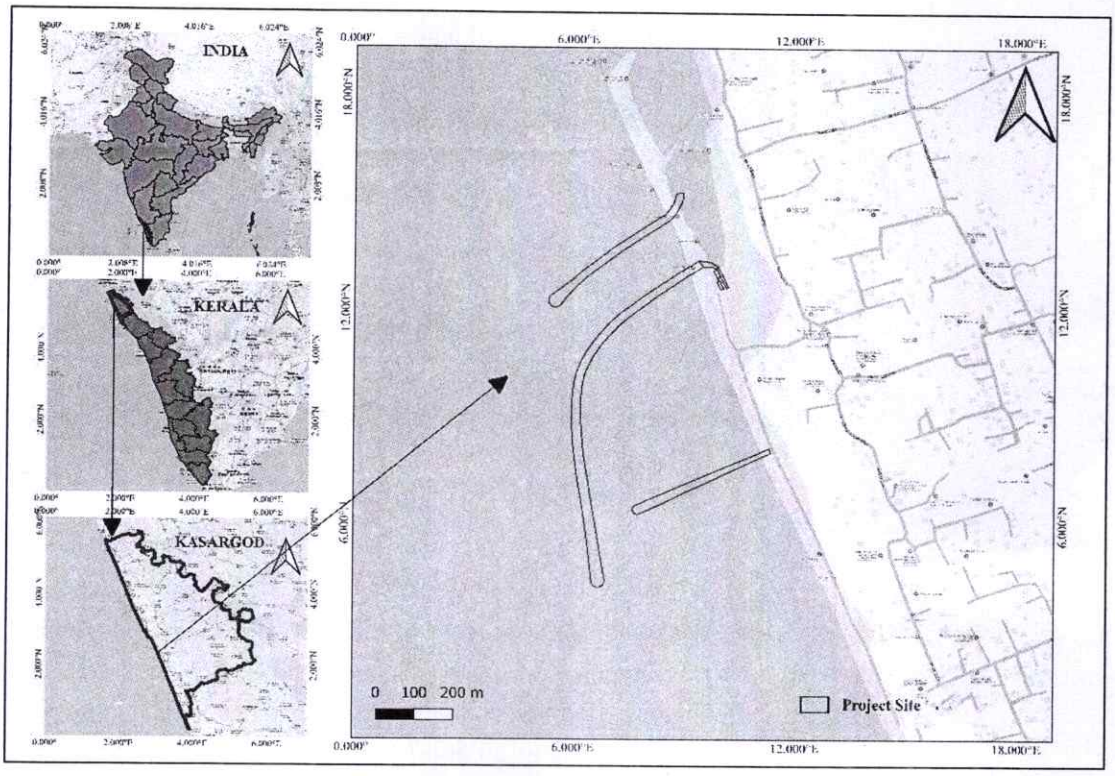


Figure 1.1: Index map of Project Site

Google earth imagery of the proposed project site is given in Figure 1.2.

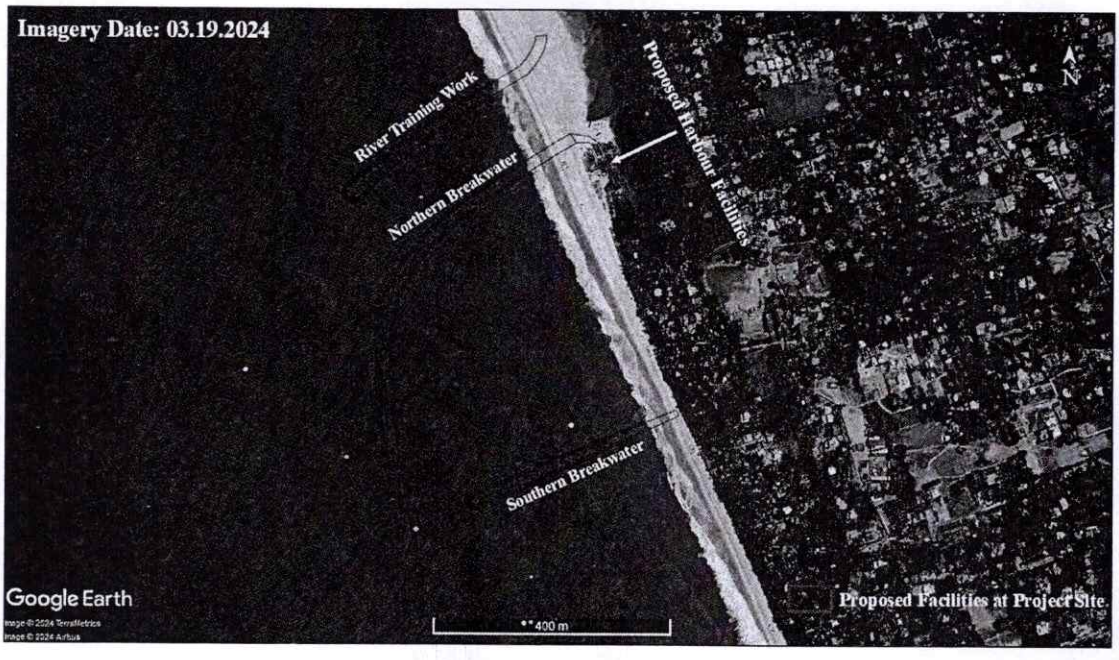


Figure 1.2: Google Earth Imagery of Proposed Project Site

Geo-tagged photographs of the project site are shown in Figure 1.3.

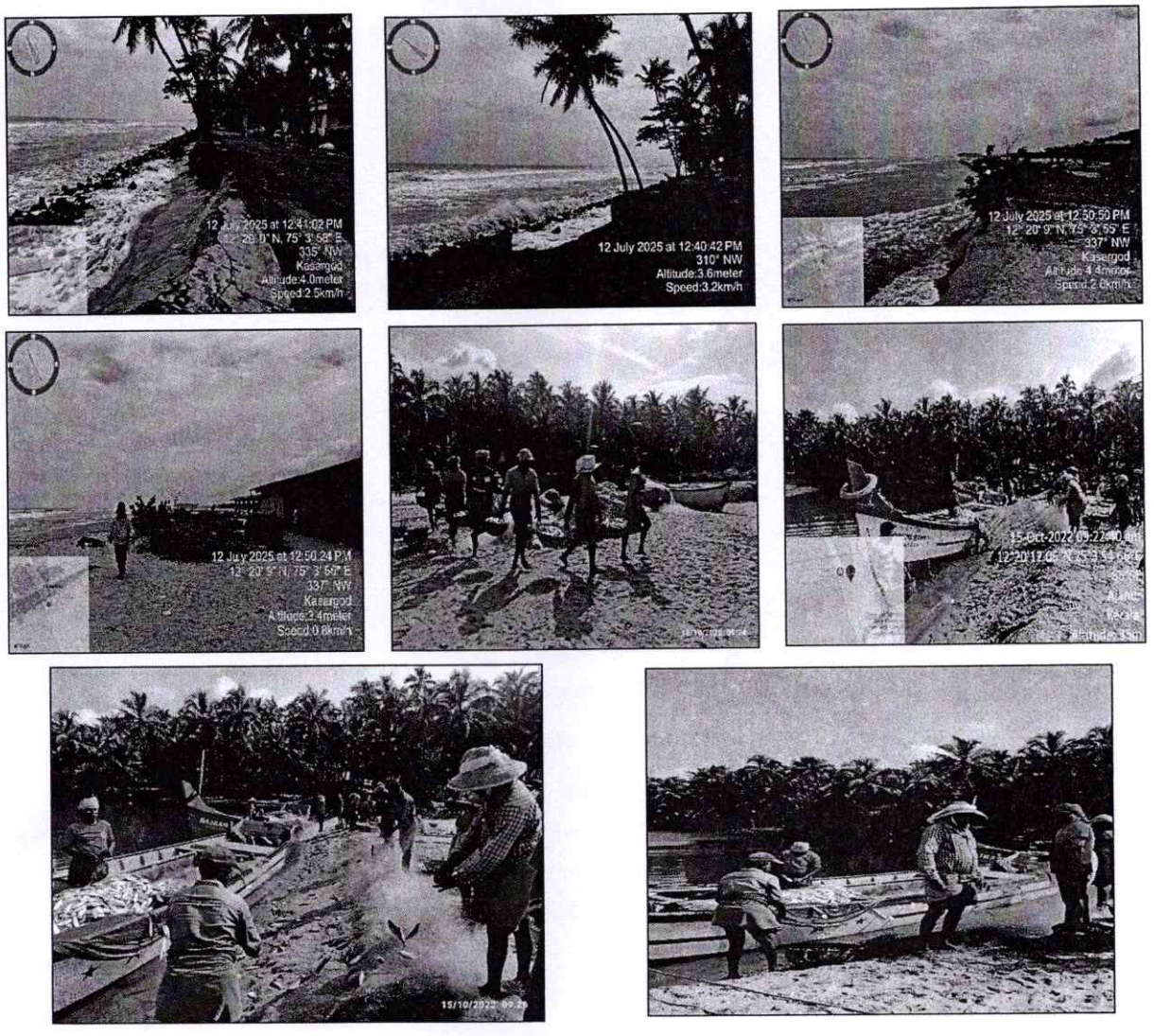


Figure 1.3: Geo-tagged Photographs of the Project Site

1.4 Project Site Description

The connectivity map to the proposed site is shown in Figure 1.4.

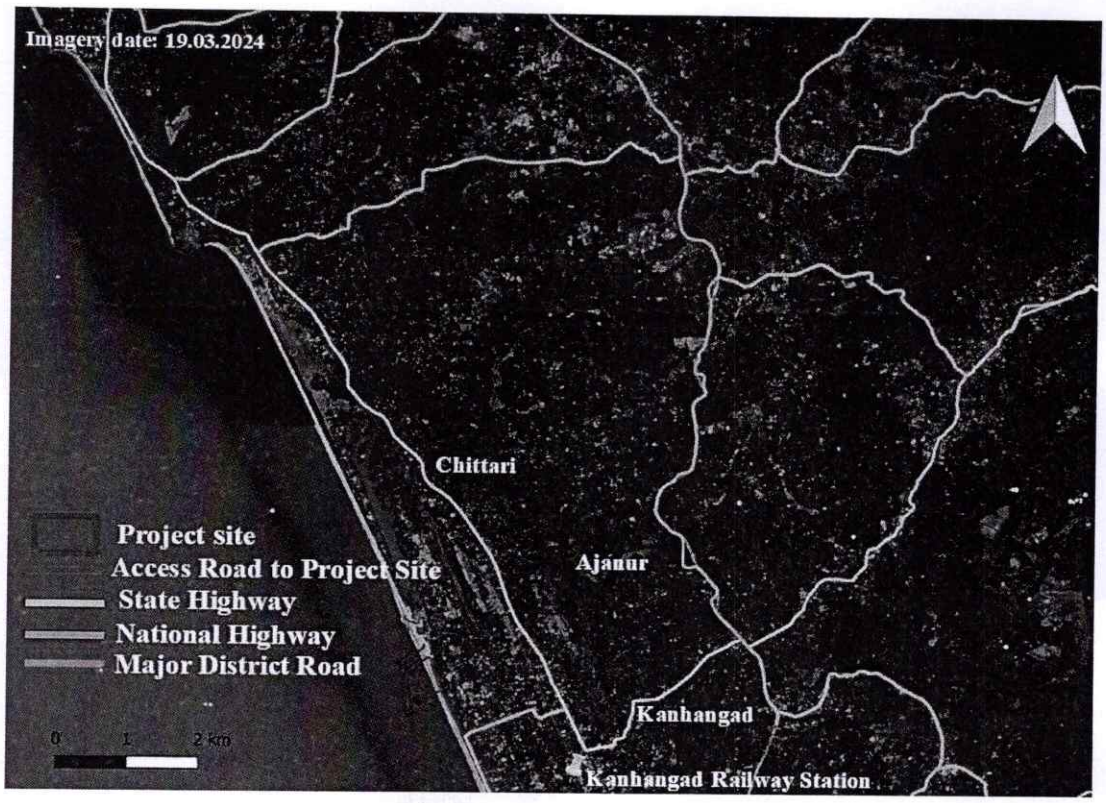


Figure 1.4: Connectivity Map of the Project Site

The proposed project site is at a distance of 2.4 km from State Highway (SH) 57 (Kasaragod – Kanhangad Highway). The access road to project site has a width of around 5 m. Existing FLC can be directly accessed from this public road. The Crescent Road and Palayi - Kanhangad Road links the access road with SH 57. It is proposed to renovate the internal roads and approach road to the proposed fishing harbour facilities.

1.5 Scope of RA&DMP Report

- The extent of the risk assessment is limited to the project site in Ajanur Village during its construction period (46 months) and operation phase.
- The field studies (reconnaissance and ground truth verification) were conducted during November 2024
- Hazard identification is done based on Kerala State Disaster Management Plan (KSDMP), 2016 and District Disaster Management Plan (DDMP), 2015 of Kasaragod district.

1.6 Objectives of the RA&DMP Report

The overall objective is to identify the significant risks from any potential hazards that may affect the safety of the users and the property and to outline the strategies, responsibilities, and actions necessary to prepare for, respond to, and recover from the potential hazards and to improve the overall resilience of the project to any potential hazards.

- Identify and assess potential hazards during the construction and operation phases of the proposed project of construction of Ajanur Fishing Harbour at Ajanur Village, Kasaragod Taluk, Kasaragod District, Kerala.

- Analysis of the significance of risks from the identified hazards.
- Develop and implement mitigation strategies for the significant risks to reduce the impact of disasters on life, property and the environment.
- Establish emergency management plan for emergency preparedness and emergency response; review and update it to ensure continuous improvement.
- Facilitate post-disaster recovery.

Chapter 2. Hazard Identification and Risk Analysis

2.1. Hazards identified by Kerala State Disaster Management Authority

The Kerala State Disaster Management Authority (KSDMA) has identified about 40 hazards likely to occur in the State, which include natural and anthropogenic hazards. The hazards reported in the State Disaster Management Plan (SDMP), 2016 of Kerala is given in Table 2.1.

Table 2.1: Hazards Identified by KSDMA

S. No.	Hazards in SDMP 2016	
	Category	Type
1.	Natural Hazards	Flood (Riverine, Urban and Flash Floods)
2.		Landslides (includes debris flows, rock fall, rock avalanche, rockslide, landslips and mud slips
3.		Drought
4.		Coastal hazards (High waves, Storm surges, Kallakadal, Tsunami, Salt Water Intrusion, Coastal erosion)
5.		Wind (Cyclone, Gustnados, Gusty winds)
6.		Lightning
7.		Earthquake
8.		Human epidemics
9.		Plant disease epidemics and pest attack on crops
10.		Avian epidemics
11.		Animal epidemics
12.		Pest attack of human habitations
13.		Forest Fire
14.		Meteorite/asteroid impacts
15.		Soil Piping
16.		Heat wave/sunburn/sunstroke
17.		Natural background radiation
18.	Anthropogenic Hazards	Stampedes
19.		Fire crackers accidents
20.		Petro-chemical transportation accidents
21.		Industrial accidents
22.		Dam break
23.		Dam spillway operation related floods & accidents
24.		Oil spill
25.		Road accidents involving civilian transport vehicles
26.		Human induced forest fire
27.		Human-animal conflicts
28.		Fire accidents in buildings and market places
29.		Boat capsizing
30.		Accidental drowning

S. No.	Hazards in SDMP 2016	
	Category	Type
31.		Building collapse
32.		Hooch accident
33.		Air accidents
34.		Rail accidents
35.		Terrorism, riots and Naxalite attacks
36.		Nuclear and radiological accidents
37.		Space debris impacts
38.		Biological accidents
39.		Occupational and recreational area related hazards
40.		Accidents in Armed Forces premises

Source: SDMP Kerala, 2016

2.2. Hazards identified by District Disaster Management Authority

The District Disaster Management Authority (DDMA) of Kasaragod identified various hazards specific to Kasaragod district, as reported in the DDMP Kasaragod, 2015. The hazards identified by the DDMA are depicted in Table 2.2.

Table 2.2: Hazards Identified by DDMA, Kasaragod District

S. No.	Classification	Type of Disaster
1.	Naturally Triggered/ Weather Related	Flood
		Coastal Hazards (Tsunami, Coastal erosion, Kallakadal, Storm surge)
		Thunder and lightning
		Cyclone
		Drought
2.	Geological	Landslides
3.	Biological	Epidemics
		Cattle epidemics
		Food poisoning
		Pest attack
4.	Anthropogenically/Technologically Triggered	Fireworks accidents
		Road accidents
		Human triggered forest fire
		Stampede
		Short circuit and related fire
		Building collapse
		Boat capsizing
		Tourism related drowning
		Rail accidents
		Hooch accident

Source: DDMP Kasaragod, 2015

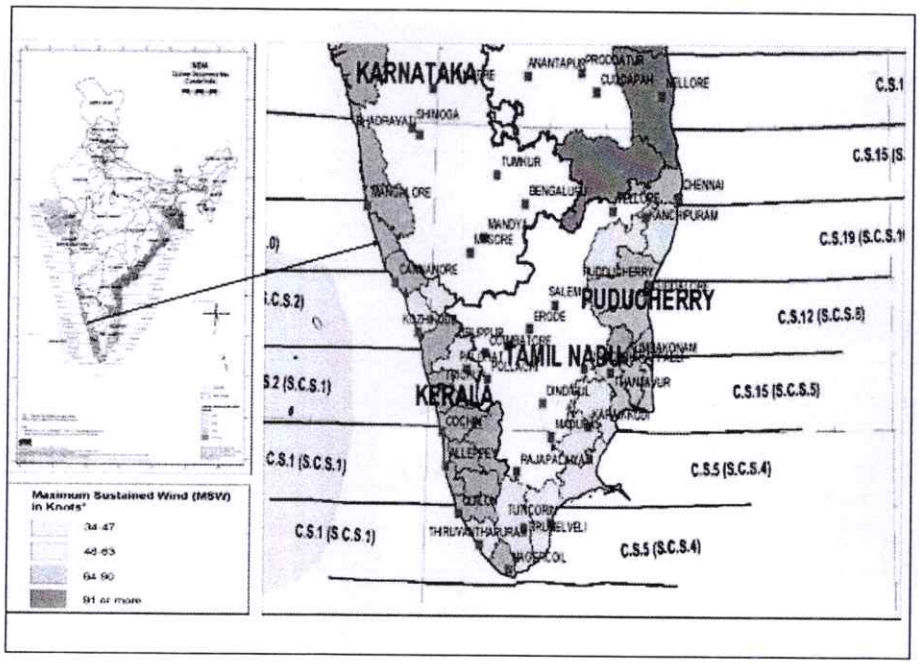
2.3. Identification of the project site specific hazards

2.3.1 Natural Hazards

During the construction phase of the project, natural disasters can cause damage to construction materials, machinery and equipment as well as accidents/ loss of life of construction workers. During the operation phase, an occurrence of natural disaster can lead to loss of life and property at the project and also of nearby residents.

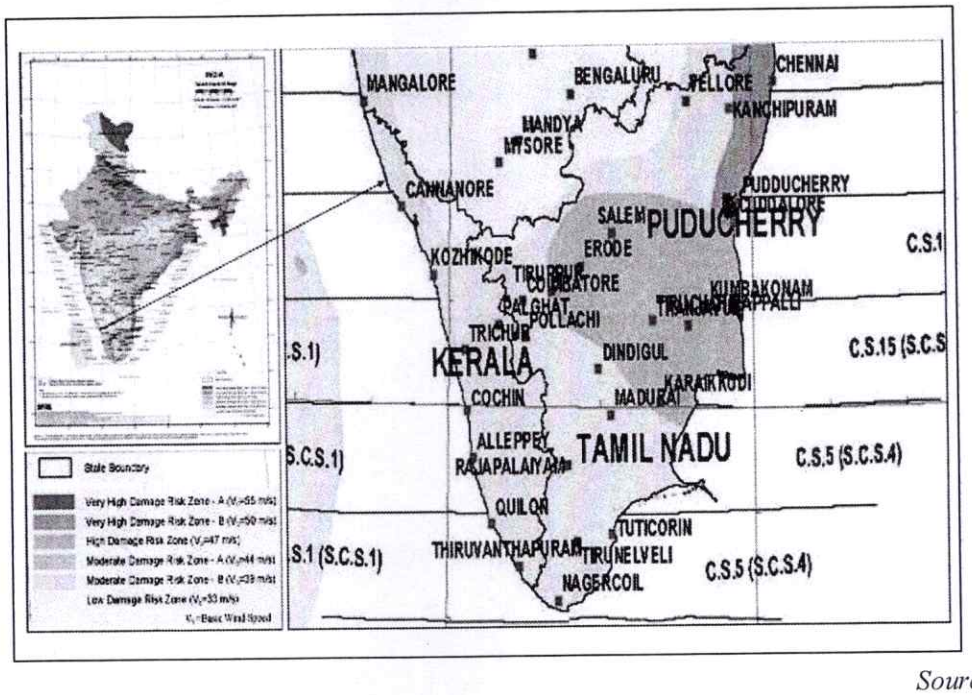
a) Cyclone

The number of cyclones formed over the Arabian sea/ Lakshadweep Sea has increased dramatically, causing concerns in the state of Kerala. The proximity of the project to the Arabian sea/ Lakshadweep sea increases the hazard susceptibility from cyclones. As per the Cyclone Hazard Map prepared by the Building Materials and Technology Promotion Council (BMTPC) in 2010 (Figure 2.1), the Maximum Sustained Wind (MSW) at the project site is 34-47 Knots. As per the Wind Hazard Map published by BMTPC (Figure 2.2) the project site falls within the moderate damage risk zone - B with basic wind speed (Vb) of 39 m/s. Cyclones can cause threat to the life of the on-site workers during construction phase and operation phase of proposed project. There could be chances of short circuiting, damage to the structures, etc. due to cyclones.



Source: BMTPC

Figure 2.1: Cyclone Hazard Map of the Project Site

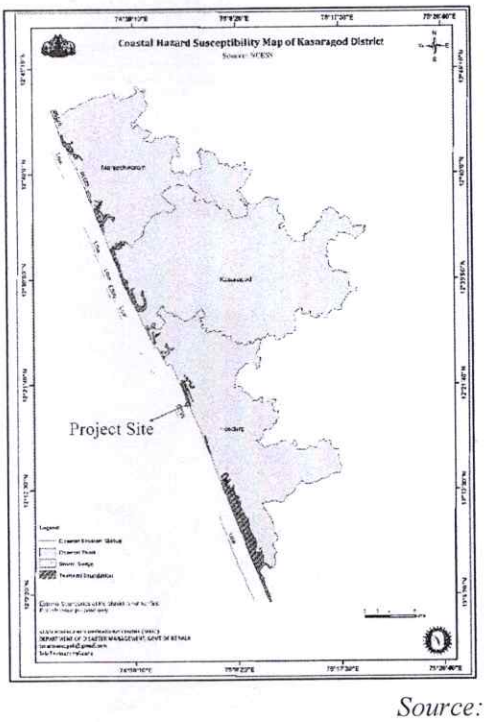


Source: BMTPC

Figure 2.2: Wind Hazard Map for the Project Site

b) Coastal Hazards

As per the coastal hazard susceptibility map of Kasaragod district prepared by NCESS for DDMP 2015, the project site falls in storm surge and tsunami inundation region. The Coastal Hazard Susceptible Map of Kasaragod district is given in Figure 2.3.

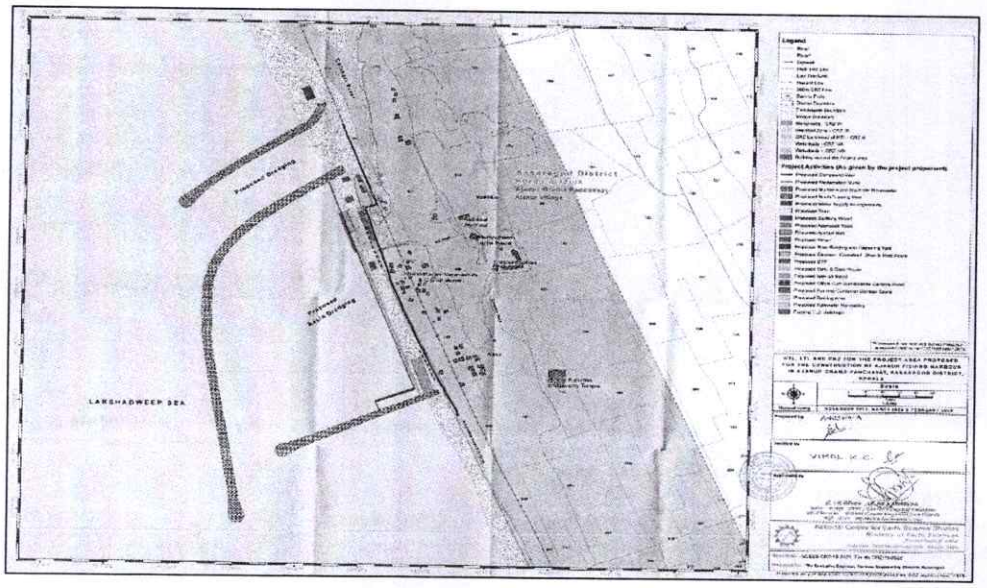


Source: DDMP 2015, Kasaragod

Figure 2.3: Coastal Hazard Susceptibility Map of Kasaragod District

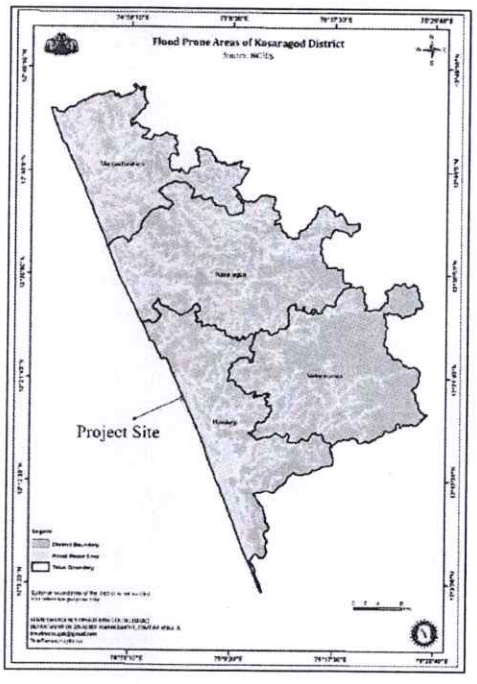
c) Flood

The 'hazard line', which indicates the maximum landward limit of flooding and water level rise, passes near the proposed project site. The CRZ map showing the proximity of the hazard line to the project site is given in Figure 2.4. The hazard line is not a regulatory boundary but an essential tool for disaster preparedness. As per the flood prone area map of Kasaragod district prepared by NCESS for DDMP, Kasaragod – 2015 given in Figure 2.5, project site is falls under flood prone area.



Source: CRZ Status Report prepared by NCESS

Figure 2.4: CRZ Map of the Project Site

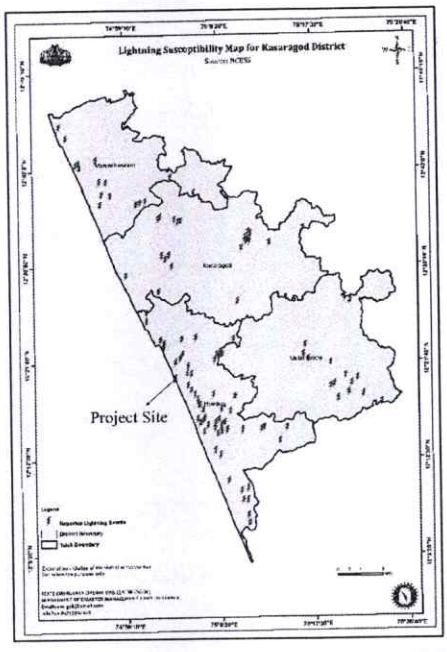


Source: DDMP Kasaragod, 2015

Figure 2.5: Flood Prone Area Map of Kasaragod District

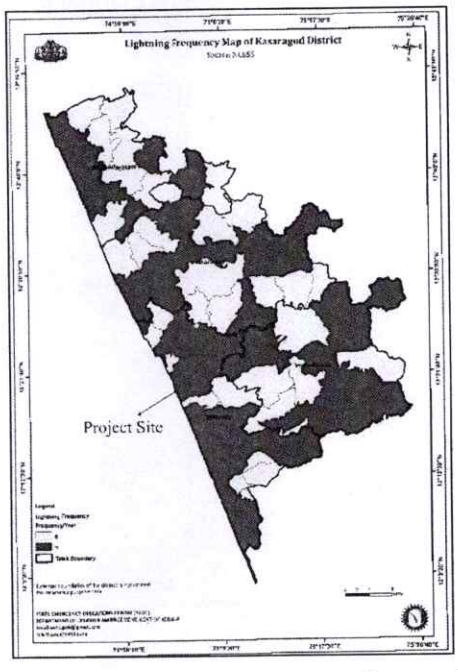
d) Lightning

As per DDMP – 2015 of Kasaragod district, the project site is near to lightning susceptible area and lightning frequency per year for the project site is 1. However, no history of lightning was reported by the locals during the socioeconomic survey. Lightning susceptibility map of Kasaragod district is shown in Figure 2.6 and lightning frequency map of Kasaragod district is shown in Figure 2.7.



Source: DDMP Kasaragod, 2015

Figure 2.6: Lightning Susceptibility Map of Kasaragod District



Source: DDMP Kasaragod, 2015

Figure 2.7: Lightning Frequency Map of Kasaragod District

e) Landslide

As per the landslide susceptibility map of Kasaragod district given in Figure 2.8, the project site is not falling in landslide susceptible area. Nearest hazard zone is low hazard zone, which located 6.5 km, E from northern breakwater.

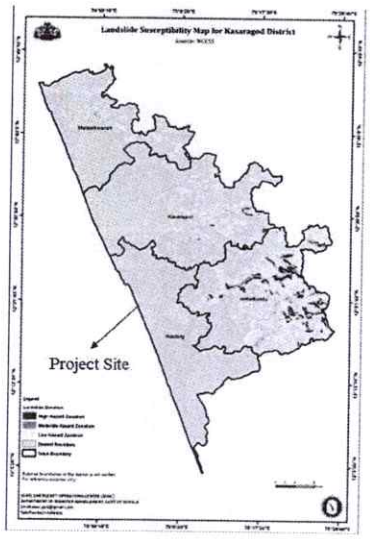
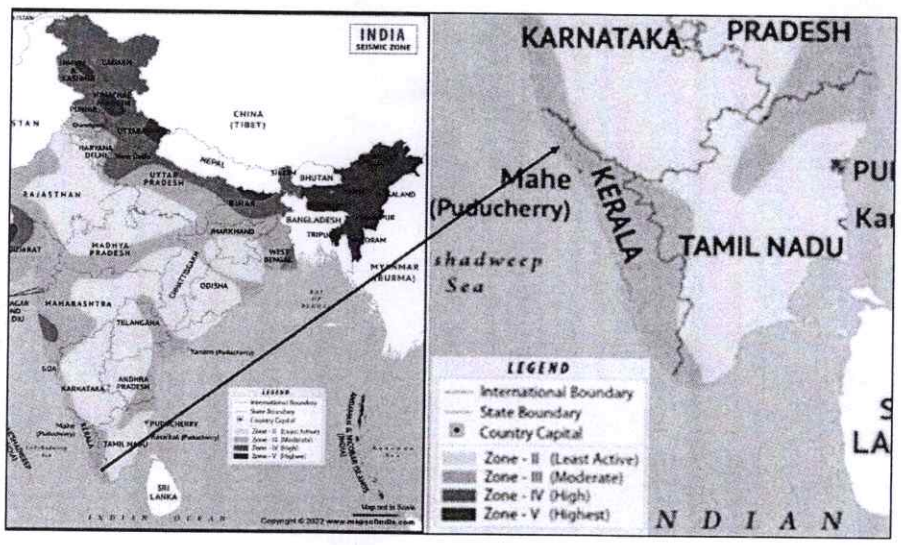


Figure 2.8: Landslide Susceptibility Map
Source: DDMP 2015, Kasaragod

f) Earthquake

As per the Seismic Zone classification by IS 1893 (Part-I): 2002 prepared by Geological Survey of India (GSI) the proposed project site is falls under Seismic Zone III (Moderate Risk Zone). The Seismic Zone Map of the project site is given in Figure 2.9

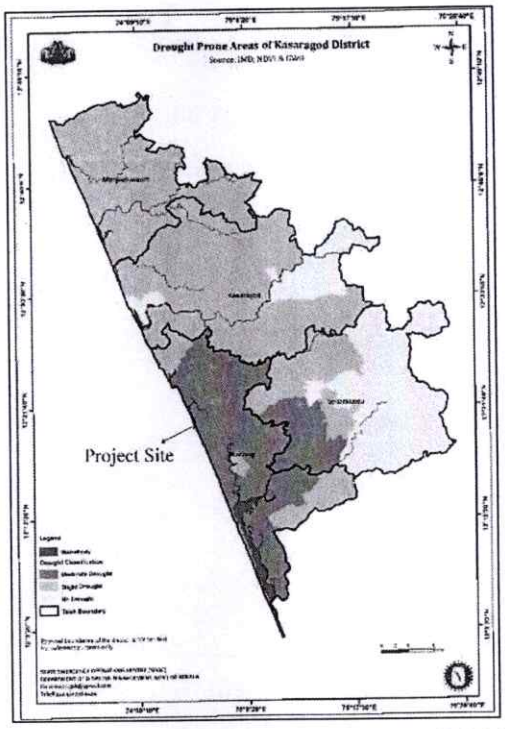


Source: Geological Survey of India

Figure 2.9: Seismic Zone Map of the Project Site

g) Drought

As per the Drought Prone Area Map of Kasaragod district in DDMP 2015, the proposed project site is located in moderate drought area. Drought Prone Area Map of Kasaragod district is given in Figure 2.10.



Source: DDMP Kasaragod, 2015

Figure 2.10: Drought Prone Area Map of Kasaragod District

h) Epidemics

As the proposed project is a construction of harbour with a workforce sourced from various locations, epidemics can spread rapidly during outbreak periods, especially if workers and suppliers come from different regions. Not following necessary regulations imposed by the concerned regulatory authorities during an epidemic can lead to a significant risk of disease spread among the workforce and nearby communities.

2.3.2 Anthropogenic Hazards

The occurrence of disaster as the result of anthropogenic activities is due to the human intervention.

a) Hazards during Construction Phase

Hazards identified during the construction phase are given below:

- Oil & chemical spills
- Vessel Collisions
- Boat capsizing
- Accidental drowning
- Accidents at the construction site on the land like falling from heights, tripping, etc.

b) Hazards during the Operation Phase

Hazards identified during the operation phase are given below:

- Design deficiencies
- Damage to the structures
- Inadequate disposal of waste
- Overcrowding within the auction hall and its surroundings

2.4. Summary of the project site specific hazards

The possible hazards identified for proposed project are given in Table 2.3.

Table 2.3: Types of Hazards Identified for the Project

Natural Calamities		Anthropogenic Hazards
Weather related: • Coastal Hazard • Flood • Cyclone • Earthquake • Lightning • Drought	**Biological:** • Epidemics	• Accidents during construction phase • Accidents during operation phase

2.5. Risk assessment for the project site specific hazards

2.5.1 Consequences Assessment

The risk consequence levels are defined, for the purpose of the quantification of the risk assessed. These are given in Table 2.4. The consequence levels are defined based on the severity of impact due to the hazard, on people, environment and property.

Table 2.4: Risk Consequence Levels

Risk Levels	Consequence	Qualitative Description of Impact on		
		People	Environment	Property
1	Insignificant (Manageable)	Event does not result in injury (no medical treatment required)	No damage	No damage
2	Minor (Short term, manageable)	Reversible injury or illness	Minor impact of short duration or short-term damage	Minor damage
3	Moderate (Medium term)	Irreversible disability or impairment to one or more persons	Short term damage resulting in complaints, localized impact	Moderate damage
4	Major (Long term)	Severe injuries to one or more persons, single fatality	Significant impact locally and potential for off-site impacts	Major damage

Risk Levels	Consequence	Qualitative Description of Impact on		
		People	Environment	Property
5	Catastrophic (Irreversible, permanent)	Multiple fatalities or irreversible injuries	Significant impacts to regional ecosystems and threatened species potential for widespread off-site impacts	Significant loss

2.5.2 *Standard Risk Assessment Matrix*

The risk assessment matrix for the proposed project is developed on the basis of the likelihood of the risk and consequences levels. The Risk Assessment Matrix is given in Table 2.5.

Table 2.5: Standard Risk Assessment Matrix

Risk Probability/ Likelihood	Consequences				
	Catastrophic (Irreversible, permanent) (5)	Major (Long term) (4)	Moderate (Medium term) (3)	Minor (Short term, manageable) (2)	Insignificant (Manageable) (1)
Almost certain (5)	Extreme (25)	Extreme (20)	High (15)	Medium (10)	Medium (5)
Likely (4)	Extreme (20)	High (16)	High (12)	Medium (8)	Low (4)
Possible (3)	High (15)	High (12)	Medium (9)	Medium (6)	Low (3)
Unlikely (2)	Medium (10)	Medium (8)	Medium (6)	Low (4)	Low (2)
Rare (1)	Medium (5)	Low (4)	Low (3)	Low (2)	Low (1)

2.5.3 *Project Specific Consequence Analysis and Risk Assessment*

Site and project specific risk assessment matrix, before the adoption of any sort of mitigation measures are depicted in Table 2.6.

Table 2.6: Project Specific Risk Assessment Matrix (without Mitigation Measures)

S. No.	Hazards	Likelihood	Consequences	Level of Risk (without mitigation)
Naturally Triggered / Weather Related Hazards				
1.	Cyclone	Possible (3)	Major (4)	High (12)
2.	Lightning	Possible (3)	Moderate (3)	Medium (9)
3.	Earthquake	Unlikely (2)	Moderate (3)	Medium (6)
4.	Drought	Possible (3)	Moderate (3)	Medium (9)
5.	Flood	Possible (3)	Moderate (3)	Medium (9)
6.	Coastal Hazard	Possible (3)	Major (4)	High (12)

S. No.	Hazards	Likelihood	Consequences	Level of Risk (without mitigation)
7.	Epidemics	Unlikely (2)	Moderate (3)	Medium (6)
Anthropogenic / Technologically Triggered				
1.	Accidents during construction phase	Likely (4)	Major (4)	High (16)
2.	Accidents during operation phase	Possible (3)	Moderate (3)	Medium (9)

It is noted that among the natural hazards, cyclone, and coastal hazard present a high level of risk, while lightning, earthquake, drought, flood and epidemics pose a medium level of risk. Regarding anthropogenic hazards, the risks anticipated from accidents occurring during the construction phase is assessed as high and for the operational phase is assessed as medium. This analysis restates the significance of adopting site and project specific mitigation measures for reducing the risks.

Chapter 3. Mitigation Measures for the Identified Risks

The likelihood and consequences of the project specific risks can be managed by suitable planning and execution in the construction and operation phases of the project. The important aspects of preparedness for risk management and mitigation measures that shall be followed to reduce the consequence of risks are:

- Design measures shall be given prime importance in reducing the risks. The design of proposed structures shall be as per the standards and Indian Standard (IS) code.
- Close co-ordination with the DDMA, Kasaragod district shall be done, to obtain early warnings of any natural disasters.
- Adequate safety measures, sign boards and warning signals shall be installed and regularly monitored.
- Sufficient number of staffs trained in first aid measures shall be deployed at the site at all times.
- Establish regular maintenance schedules for emergency devices and systems, such as lighting and structural monitoring equipment, to ensure they remain fully operational at all times.

The preparedness for specific risks related to the project is detailed in the following sections.

3.1 Proposed Mitigation Measures for Identified Risks

The mitigation measures that shall be scrupulously followed specifically against the identified risks are given below:

3.1.1 Cyclone

- Technical assistance for early warning and hazard risk mitigation shall be obtained from DDMA Kasaragod.
- Emergency response team shall be activated immediately upon receiving timely warning from DDMA and adequate measures shall be taken when a warning for cyclone is issued to evacuate the workers.
- Construct harbor buildings, warehouses, and shelters using cyclone-resistant materials and design standards.
- During cyclone warnings, all loose cargo, containers, and equipment should be secured or moved to safer storage areas to prevent them from becoming projectiles in high winds.

3.1.2 Coastal Hazards

- Implement and maintain an early warning system for fishermen and harbour authorities to receive real-time alerts about tsunamis or high wave activities.
- Set up clear evacuation protocols and disseminate knowledge about safety measures during coastal emergencies.
- Restore natural sand dunes and plant mangroves or other salt-tolerant vegetation as natural buffers against storm surges and coastal erosion.

3.1.3 Flood

- Synchronize the operation schedule with meteorological warnings to avoid work during heavy rain.
- Set up flood warning systems to alert harbour authorities, ship operators, and personnel, enabling them to take precautionary measures.
- Ensure that the harbour receives real-time data on weather conditions.
- Enhance storm water drainage systems to handle excess rainwater and prevent flooding within the

harbour area. Ensure regular maintenance to keep drains and culverts clear of debris.

- Use flood-resistant materials for buildings and equipment near the waterfront.

3.1.4 Lightning

- Provide lightning arrestors in the building at the landside facilities of the harbour.
- Regularly monitor weather forecasts and issue warnings when thunderstorm forecasts.
- Use audible or visual alarms in outdoor and exposed areas of a harbour to warn personnel of approaching lightning storms.
- Implement protocols to suspend operations during thunderstorms.
- Establish designated lightning-safe shelters like fully enclosed buildings for workers.

3.1.5 Earthquake

- Emergency evacuation plan along with safety measures shall be implemented. All the information and instructions from concerned department and DDMA shall be scrupulously followed.
- Design and construct buildings and infrastructure to comply with national seismic building codes that account for earthquake forces.

3.1.6 Drought

- The project proposes to reduce its dependence on groundwater by harvesting and reuse of rainwater collected from the roof of buildings proposed in the harbour.
- Apart from this, measures shall be explored for the recharge of storm runoff into the groundwater.

3.1.7 Epidemics

- Regulations issued by the concerned regulatory authorities in the event of an epidemic shall be scrupulously followed at the site during the construction phase.
- To avoid the spread of epidemics among the workers, they shall be educated on the importance of timely consulting a doctor, taking necessary vaccinations, and following safety precautions like wearing masks, using sanitizers, etc.
- Adequate provisions shall be provided at the site to immediately isolate and give proper medical care to the workers with symptoms.
- Measures shall be implemented to restrict pests, animals, and birds from entering the site, by the installation of fencing, pest control, and regular monitoring of potential entry points, to prevent the displacement of waste.
- Stormwater management system during monsoon season must be ensured

3.1.8 Accidents during Construction Phase of the Project

- Ensure safe storage and handling of oil and hazardous chemicals.
- Ensure emergency response equipment like protective gear, absorbents, neutralizing agents, and containment booms are readily available.
- Implement continuous monitoring of water and soil quality in and around the harbour to detect any signs of contamination early and take immediate corrective action.
- Ensure that all machinery operators receive thorough training on equipment use, safety procedures, and emergency protocols. Regular refresher courses should also be provided.

- Schedule construction activities to avoid the peak erosion periods, such as during the rainy season or high-wave conditions, to minimize the risk of erosion.
- Install temporary barriers or sandbags to protect construction sites and adjacent coastal areas from erosion caused by storms or high waves.
- Ensure boats are loaded safely and within capacity.
- Implement physical barriers or restricted access to dangerous water areas where drowning risks are high, such as construction sites or deep bodies of water.
- Develop and communicate a detailed emergency response plan for drowning incidents, including procedures for rescuing individuals, administering first aid, and contacting emergency services.

3.1.9 Accidents during Operation Phase of the Project

- Hazardous materials shall be stored in designated locations after obtaining necessary approvals.
- The leachable materials shall be stored in closed containers/leak proof packaging.
- Sufficient number of staff trained in first aid measures shall be deployed at the site at all times.
- Adequate number of first aid kits shall be provided.
- Fishers shall be encouraged to use adequate PPE & adequate safety measures shall be installed and regularly monitored.
- Skilled workers shall be chosen for operating the machineries.
- Develop and enforce traffic management plans to ensure the safe movement of vehicles and vessels within the harbour.
- Install and maintain clear and visible safety signs and warnings around the harbour to alert personnel and visitors to potential hazards and safety procedures.
- Establish and enforce standard operating procedures (SOPs) for all harbour operations, including emergency response to ensure consistency and safety.
- Continuously monitor weather conditions and implement protocols to suspend operations or take precautionary measures during adverse weather conditions, such as storms or high winds.
- Maintain reliable communication systems for coordination among personnel, ships, and emergency services. Use radios, alarms, and signaling devices to ensure effective communication.
- Conduct regular risk assessments to identify potential hazards and vulnerabilities in harbour operations. Use the findings to update safety protocols and mitigation measures.
- Implement measures to prevent environmental contamination, such as proper waste disposal, spill response systems, and monitoring of water quality to detect any potential pollution early.

3.2 Updated Risk Assessment Matrix with Mitigation Measures

The implementation of mitigation measures reduces the likelihood and consequences of the hazards. Reduction of the likelihood of risk and level of consequences reduces the overall level of risk, as shown in Table 3.1.

Table 3.1: Project Specific Risk Assessment Matrix with Mitigation Measures

S. No.	Hazards	Level of Risk (without mitigation)	Likelihood	Consequences	Level of Risk (with mitigation)
Naturally Triggered / Weather Related Hazards					
1.	Cyclone	High (12)	Possible (3)	Moderate (3)	Medium (9)
2.	Lightning	Medium (9)	Possible (3)	Minor (2)	Medium (6)
3.	Earthquake	Medium (6)	Unlikely (2)	Minor (2)	Low (4)
4.	Drought	Medium (9)	Possible (3)	Insignificant (1)	Low (3)
5.	Flood	Medium (9)	Possible (3)	Minor (2)	Medium (6)
6.	Coastal Hazard	High (12)	Possible (3)	Moderate (3)	Medium (9)
7.	Epidemics	Medium (6)	Unlikely (2)	Minor (2)	Low (4)
Anthropogenic / Technologically Triggered					
1.	Accidents during construction phase	High (16)	Unlikely (2)	Minor (2)	Low (4)
2.	Accidents during operation phase	Medium (9)	Unlikely (2)	Minor (2)	Low (4)

The targeted mitigation measures implemented in the proposed construction have significantly minimized the potential impact of identified risks, as clearly evidenced in the updated Risk Assessment Matrix. By proactively addressing critical hazards, these measures have effectively minimized the probability of occurrence and mitigated the intensity of their impacts. As a result, the overall risk levels have been substantially reduced, enhancing the safety and stability of operations. This approach highlights the success of risk management strategies and establishes a strong basis for ongoing risk reduction efforts.

Chapter 4. Emergency Management Plan

The RA&DMP has identified the safe transition from normal operation to emergency operations and systematic discontinuation of the construction and operation activities, if required, and the delegation of authority from operations personnel to emergency response personnel. For this purpose, the plan has identified an emergency preparedness measures with appropriate lines of authority with succession planning and actuating the response management which ensures a proactive and structured response to potential emergencies that may arise in the proposed construction of Ajanur Fishing Harbour, due to natural or anthropogenic hazards.

4.1 Emergency Preparedness Measures

As emergency preparedness measures, the following services shall be made available at the site to ensure efficient implementation of the emergency management plan:

4.1.1 Emergency Response Team

For the safe transition from normal operation to emergency operations and systematic shutdown during the emergency, an Emergency Response Team with appropriate lines of authority with succession planning and actuating the response management at site has been identified. Objective of an Emergency Response Team are:

- To promptly control problems as they develop at the site.
- To prevent or limit the impact on other areas.
- To provide emergency personnel, selecting them for duties compatible with their normal work functions wherever feasible. The duties & functions assigned to various people include making full use of existing organizations and service groups such as fire, safety, health, medical, transportation, personnel, maintenance, and security.
- Employees must assume additional responsibilities as per laid down procedure of DMP whenever an emergency alarm sounds.
- In setting up the organization, the need for round-the-clock coverage is essential. Shift personnel must be prepared to take charge of the emergency control functions or emergency shutdown of system, if needed, until responsible personnel arrive at the site of emergency. The organization should have an alternate arrangement for each function.
- Internal safety audits shall be conducted at regular intervals to ensure that all necessary equipment and facilities for an emergency response is rightly maintained and is up-to-date. It shall be also ensured the workers are given refresher training for emergency preparedness and rescue.

The emergency organization is responsible to take over the site activities in case of a hazard and to act promptly to control the event and to restore back the site post the hazardous event. The responsibilities for decision making are clearly shown in the emergency organization chart. The plan has identified each responder's position, mission, duties and reporting relationship. An organization chart of the emergency management team is shown in Figure 4.1.

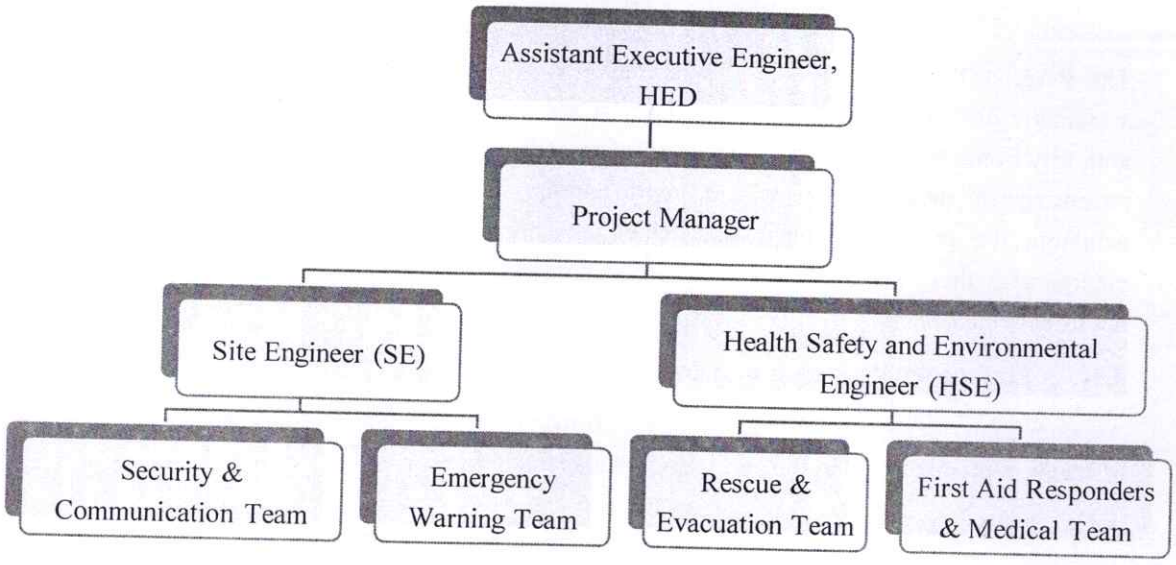


Figure 4.1: Organogram of Emergency Response Team for the Project

The emergency notification process in case of emergency situation is given in Figure 4.2.

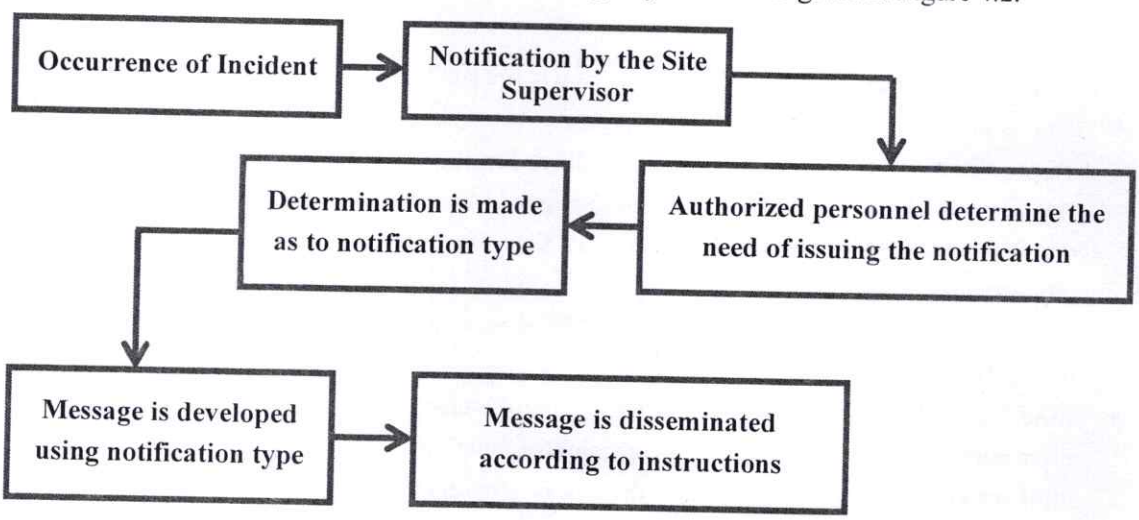


Figure 4.2: Emergency Notification Process

4.1.2 Roles and Responsibility of Emergency Response Team

The general roles and responsibilities of proposed emergency management personnel to prevent and mitigate an unfavorable event to minimize its adverse impact are:

- Look into the structural safety requirements for various hazards (fire, cyclone, etc.). Get the proposed structure assessed for the hazards identified and take prompt remedial measures, as required.
- Evaluation and updating of the RA&DMP at regular intervals (at least once a year, and after any significant disaster) to ensure that the plan is workable.
- Earmark fund arrangements for carrying out preparedness and mitigation measures.
- Declaring emergencies and implementing the emergency plan.
- Implementing evacuation procedures.

- Ensuring coordination with external emergency services (fire, police, ambulance) and utilities.
- Assessing and obtaining emergency services, supplies and equipment.
- Ensuring the safety of the labourers at all times during an emergency.
- Contacting, training and supervising volunteers.
- Documenting all aspects of the response/recovery procedures.
- Preparing post-emergency reports.

As emergency preparedness measures, the following services shall be made available at the site to ensure efficient implementation of the emergency response plan.

4.1.3 Emergency Control Centre

The Emergency Control Centre shall be established during the construction phase of the project that is equipped with following facilities:

- Copy of current on-site emergency plan
- Display of the name of site emergency controller
- Adequate and reliable communication facilities (phone, handset etc.)
- Site layout diagram with entry and exit routes / assembly points
- Directory of internal / external emergency phone numbers
- Fire extinguishers (Dry Chemical Powder (DCP) type / Foam Type / CO_2) on site
- A set of PPEs for each and every member of the construction team as required
- List of fire trained personnel
- Appropriate numbers of rescue ropes and high beam torches
- Drinking water

4.1.4 Firefighting Systems

It shall be ensured that the following firefighting systems are established in the site for proposed construction:

- Maintain clear access for emergency vehicles.
- Fire detection systems, including smoke and heat detectors, should be implemented to ensure early detection, while a comprehensive fire alarm system can alert personnel to emergencies.
- Portable fire extinguishers should be placed in accessible locations.
- Store flammable materials like fuels, solvents, and paints in designated, well-ventilated areas away from heat sources and the storage areas should be equipped with fire extinguishers.

4.1.5 Communication Services

Adequate provision of inter-communication telephones, public address system, emergency alert system and cellular phone-based communication shall be made to ensure safe communication works during emergency response planning.

A list of emergency contact numbers, including those for fire services, police, hospital etc., should be prominently displayed in proximity to the project site. This ensures prompt access to critical contact information for immediate reporting and response during an emergency.

4.1.6 External Emergency Contacts

The contact details of concerned authorities to be contacted in case of emergency like the nearest police station, fire station, hospital etc. are given in Table 4.1. These contact details shall be displayed in all prominent locations at the site. The details of nearest emergency facilities are given in Table 4.2.

Table 4.1: External Emergency Contacts

S. No.	Official / Service	Telephone Number
1.	District Disaster Management Cell Collectorate, Kasaragod	0499 4257700
2.	Additional District Magistrate (ADM), Kasaragod	0499 4255833
3.	District Collector, Kasaragod	0499 4256400
4.	Municipal Corporation Secretary, Kanhangad	0467 2204530
5.	District Medical Officer (DMO), Kasaragod	9946105497
6.	District Hospital, Kanhangad	0467 2217019
7.	Primary Health Centre, Ajanur, Kanhangad	0467 2204985
8.	Manzoor Hospital, Kanhangad	0467 220 2070
9.	District Police Chief, Kasaragod	9497996972
10.	Hosdurg Police Station, Kanhangad	94979 80922
11.	Fire & Rescue Station, Kanhangad	0467 2202101
12.	KSEB Section Chithari Office, Kanhangad	0467 2267049

Table 4.2: Nearest Police/Fire Stations and Hospitals

S. No.	Official / Service	Road Distance from Project Site (km)	Direction
Nearest Hospital			
1.	Primary Health Centre, Ajanur, Kanhangad	1.60	SE of Southern breakwater
2.	Manzoor Hospital, Kanhangad	3.20	E of Southern breakwater
Nearest Police Station			
1.	Hosdurg Police Station, Kanhangad	5.00	SE of Southern breakwater
Nearest Fire Station			
1.	Fire and Rescue station, Kanhangad	5.00	SE of Southern breakwater

4.1.7 Trainings and Capacity Building

To ensure the safety and preparedness of all personnel, a robust training and capacity-building plan shall be implemented. Each member of the construction and operations teams, shall be provided with PPE and trained in its proper use. Regular training sessions will cover essential topics such as safety procedures, emergency response, first aid, and fire evacuation. Designated staff, including a Health, Safety, and Environment (HSE) engineer or trained crew members, will be equipped to handle medical emergencies, with first aid kits and Cardiopulmonary Resuscitation (CPR) training readily available. Workers will also be informed about emergency contact lists to ensure swift communication in the event of casualties or accidents.

Emergency response plans, including evacuation routes, assembly points and fire safety protocols, shall be developed, displayed at key locations, and communicated to all workers. Fire detection and suppression systems, such as extinguishers and water tanks, shall be strategically installed, regularly maintained, and

supported by fire drills to ensure preparedness. Measures to manage worker fatigue, such as adequate breaks and monitoring work hours, will also be implemented to promote overall safety and efficiency. The site shall undergo regular inspections and risk assessments to identify potential hazards and ensuring effective response.

4.1.8 Community Involvement

Community involvement in Emergency Management Plan, ensures that local stakeholders are informed, prepared, and engaged in the project's safety measures. Establishing clear communication channels with the local community will help in disseminating emergency information, such as evacuation plans, safety procedures, and contact details for emergency services.

4.1.9 Budgetary Allocation for Emergency Management

The following equipment and measures are recommended for the proposed project based on the hazards identified. The budget allocation for this additional measure/ equipment is detailed in Table 4.3.

Table 4.3: Cost of Emergency Management Measures for the Project

S. No.	Disaster Management Measures	Capital Cost (In INR)	Recurring Cost/year (In INR)
	Construction Phase		
1.	Conducting training sessions and disaster drills for construction workers	-	30,000
2.	Conducting awareness program for local community	-	30,000
3.	Establishing temporary safe zones for workers and materials	50,000	15,000
4.	Safety Officer	-	3,00,000
5.	PPE for workers (Helmets, gloves, safety boots, high-visibility vests, masks, life jacket etc.)	5,15,000	80,000
6.	Contingency fund for unforeseen emergencies or expenses	-	1,00,000
7.	Erecting display boards at the project site - 8 nos. ➢ Emergency contacts ➢ Diversion boards	35,000	5,000
	Budgetary Allocation for Construction Phase	***6,00,000***	***5,60,000***
	Operation Phase		
8.	Regular inspections of structures	20,000	8,000
9.	Installation of CCTV	10,000	2,000
10.	Sign boards	15,000	5,000
	Budgetary Allocation for Operation Phase	***45,000***	***15,000***

Total estimated budget for Emergency Management Measures during the construction phase is INR 6,00,000 as capital cost and INR 5,60,000 per year as recurring cost. During operation phase the budgetary allocation as capital cost is INR 45,000 and recurring cost is estimated as INR 15,000 per year.

4.2 Site Safety Checklist

A safety checklist has been prepared that has to filled by a duly appointed representative of all sectors of staff involved in the construction site. The review and analysis of the checklist helps in evaluating the efficiency

of the Emergency Preparedness Plan and for timely updating the same. The checklist prepared is given in Table 4.4.

Table 4.4: Safety Checklist to be followed at Site

S. No.	Particulars	✓/X
1.	Have all workers been provided with and are they wearing the necessary PPE?	
2.	Are temporary structures, such as scaffolding and formwork, regularly inspected for stability and security?	
3.	Has each worker received proper training on natural hazards and emergency procedures?	
4.	Is there a comprehensive emergency evacuation plan in place?	
5.	Are well-stocked first aid kits readily available on-site, and do workers know their location and how to use them?	
6.	Have effective communication channels been established to keep workers informed about potential natural hazard threats and evacuation orders?	
7.	Is there a contingency plan for flooding or water-related risks due to proximity to water?	
8.	Are safe access and egress routes to higher ground clearly marked and kept clear of obstructions?	
9.	Have electrical connections and equipment been properly waterproofed to prevent electrical risks during hazards?	
10.	Are construction materials stored in elevated areas to prevent damage during a hazard?	
11.	Are regular site inspections being conducted to identify and address potential safety hazards?	
12.	Is there a competent supervisor overseeing safety compliance and ready to respond quickly to emergencies?	
13.	Are local authorities and emergency services familiar with the construction site and emergency protocols for quick response?	
14.	Will a thorough inspection of the construction site be conducted after a hazard event to assess damages and identify safety risks?	
15.	Have past hazard incidents been analyzed to learn from them and improve safety protocols?	

4.3 Post Disaster Recovery

If the proposed structures are affected by any disaster, the following measures shall be adopted for recovery.

- A qualified engineer should assess the structural integrity
- To prevent further damage or collapse, installation of shoring or supports, reinforcing critical parts of the structure.
- Implement safety measures like debris removal and utility repairs to ensure public safety and to minimize further disruptions.
- Review the RA&DMP after the disaster and update it accordingly based on lessons learned.

Chapter 5. Conclusions and Recommendations

5.1 Conclusions

- Effective disaster management is a comprehensive process that involves planning, coordination, and continuous improvement to protect the life and properties of users, local communities and the environment, and ensure sustainable development despite the occurrence of disasters.
- The natural hazards identified for the project are coastal hazards, flood, earthquake, drought, cyclone, lightning and epidemics. The anthropogenic hazards identified are accidents possible during construction phase and operation phase of the project.
- Following the implementation of mitigation measures, the risk levels for natural and anthropogenic hazards have significantly reduced. Coastal hazard and cyclone risk have decreased from high to medium, while risk of earthquake, drought and epidemics has dropped from medium to low. Risk of flood and lightning has dropped from medium (9) to medium (6). Likewise, anthropogenic hazards have seen a reduction in risk levels from high to medium, ensuring a safer and more resilient environment.
- The estimated budget for emergency management measures is INR 6,00,000 as capital cost with a significant portion allocated for the safety of the workers while recurring cost of INR 5,60,000 per year is allocated with significant portion for the expense of safety officer. During the operational phase, the capital cost is estimated as INR 45,000 while the recurring cost is estimated as INR 15,000 per year with a significant portion allocated for maintenance.

5.2 Recommendations

- Environmental design parameters shall be given utmost importance and the design shall be prepared and implemented as per the prevailing environmental parameters at the project location to reduce risks.
- Only trained personnel shall be deployed for the construction and all related works in the water body.
- Adequate safety measures must be taken to prevent accidents during construction and operation phase of the project.
- Close co-ordination with DDMA Kasaragod district shall be done, to obtain early warnings of any natural disasters.
- All emergency contact numbers shall be prominently displayed at all important locations.
- All the staff and technicians deployed at the site shall be trained in first aid and for handling emergency situations. Adequate number of first aid kits shall be available at the project site at all times.
- The site safety compliance checklist shall be filled by an assigned representative of all sectors of the staffs employed at the construction site to ensure and enhance efficiency of the DMP.

Adoption of site-specific mitigation measures will reduce the risks at the site and emergency preparedness will help in mitigating any possible hazard likely to occur. HED is committed to ensuring the safety and security of all workers at site, fisherman and nearby residents.

HTL, LTL, AND CRZ FOR THE PROJECT AREA PROPOSED FOR THE CONSTRUCTION OF AJANUR FISHING HARBOUR IN AJANUR GRAMA PANCHAYAT, KASARAGOD DISTRICT, KERALA

(As per CRZ Notification, 2019)



Prepared for

The Executive Engineer, Harbour Engineering Division,
Kasaragod - 671 121

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
Ministry of Earth Sciences, Government of India
Thiruvananthapuram - 695 011, Kerala

MAY 2025

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Ministry of Earth Sciences, Government of India, Thiruvananthapuram

DOCUMENTATION PAGE

1.	REPORT NUMBER	NCESS-CRZ-19-2025
2.	TYPE OF REPORT	CRZ STATUS REPORT
3.	TITLE	HTL, LTL, AND CRZ FOR THE PROJECT AREA PROPOSED FOR THE CONSTRUCTION OF AJANUR FISHING HARBOUR IN AJANUR GRAMA PANCHAYAT, KASARAGOD DISTRICT, KERALA
4.	PRINCIPAL INVESTIGATOR	Dr. REJI SRINIVAS
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5.	KEYWORDS	Coastal Regulation Zone (CRZ), CRZ Notification (2019), High Tide Line (HTL), Low Tide Line (LTL), Hazard Line, CRZ IA, CRZ IB, CRZ II, No Development Zone (NDZ), CRZ IIIA, CRZ IIIB, CRZ IVA, CRZ IVB and Coastal Zone Management Plan (CZMP).
6.	ABSTRACT	The Executive Engineer, Harbour Engineering Division, Kasaragod requested the National Centre for Earth Science Studies (NCESS), Ministry of Earth Sciences, Government of India, Thiruvananthapuram, an agency authorized by the Government of India to delineate HTL and LTL to provide CRZ Maps and Status Report to facilitate CRZ clearance for the proposed construction of Ajanur fishing harbour in Ajanur Grama Panchayat, Kasaragod district, Kerala. According to the approved CZMP (as per CRZ Notification 2019), part of the project site is located in Survey Numbers 176 and 187 in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod District, Kerala. The majority of the proposed project site is situated on the Lakshadweep Sea and Poramboke land on the outskirts of Ajannur Village. As per the project layout and DPR provided by the project proponent, the proposed construction of Ajanur Fishing Harbour consists of a north breakwater of 1150 m in length, and south breakwater of 425 m length, a north training wall of 435 m in length, a wharf, auction hall, parking area, toilet, water supply arrangements, canteen/gearshed/shop/rest room, gate & gatehouse, internal road, boat building & repairing yard, reclamation bund, packing container storage space, office cum surveillance camera room, ETP, rainwater harvesting, compound wall, approach road, basin dredging, berthing wharf and dredging near training wall. The project site also includes the existing buildings of the fish landing centre, which comprises the net mending building, an auction hall, and a toilet block. The total estimated cost of the project, including all components, is Rs. 20,000 lakhs. The proposed project area is directly accessible via the Ajanur Fish Landing Centre Coastal Road. Additionally, it can be reached through Crescent Road, which runs parallel to the seacoast and connects with Ajanur Fish Landing Centre Coastal Road. The project area falls within the Coastal Regulation Zone of the Lakshadweep Sea and Chithari River and is part of Map No. KL - 78 (Sheet No. D 43 V 3/SW) of the CZMP of Kerala (approved in 2024) prepared as per the CRZ Notification, 2019. The CRZ map is prepared in 1:4000 scale cadastral base map with survey plot information. The proposed project site has High Tide Line on the seaside and the riverside. According to the approved CZMP (as per CRZ Notification, 2019) map, ecologically sensitive areas such as mangroves are not depicted in the project site or close vicinity. However, during the field survey, mangrove patches were observed within the project area and its vicinity along Chithari Riverbanks, which have been incorporated into the CRZ map. Along the coastline, dense settlements are observed in the vicinity of the project area, especially the southern side of the project site, and a sandy beach is observed on the seaward side of the Fish Landing Centre Road. According to the approved Coastal Zone Management Plan (CZMP) of Kerala as per CRZ Notification 2019, part of the project area is located in Ajanur Grama Panchayat of Ajanur Village (other part of the project area located in the Lakshadweep Sea and Poramboke land), which is a category-1 legally designated Urban Area; hence, it is categorized as CRZ II. The proposed project activities fall within the CRZ IA (Mangroves), CRZ IB (Intertidal Zone), CRZ II, CRZ IVA (Lakshadweep Sea), and CRZ IVB (Chithari River) categories. The existing FLC Buildings fall within the CRZ IB (Intertidal Zone) and CRZ II categories. As per CRZ Notification 2019, Paragraph 5.1.2, activities shall be regulated or permissible in CRZ IB areas as under Clause (i), ie. "land reclamation, bunding, etc. shall be permitted only for activities such as (Sub-clause (a)) foreshore facilities like ports, harbours, jetties, wharves, quays, slipway, bridges, hover ports for coast guard, sea links, etc.," and Clause (ii) ie. "the activities related to waterfront or directly needing foreshore facilities such as ports and harbours, jetties, quays, wharves, erosion control measures, breakwaters, pipelines, lighthouses, navigational safety facilities, coastal police stations, Indian coast guard stations and the like". As per CRZ Notification 2019, Paragraph 5.2, Clause (i), the activities permitted in CRZ IB shall also be permissible in CRZ-II, as applicable. As per CRZ Notification 2019, Paragraph 5.4, activities shall be permitted and regulated in CRZ IV areas as under Clause (ii), ie. "land reclamation, bunding, etc. to be permitted only for activities such as (Sub-clause (a)) foreshore facilities like ports, harbours, jetties, wharves, quays, slipways, bridges, sea links and hover pots for the coast guard, etc., and Clause (iii) ie. "activities related to waterfront or directly needing foreshore facilities, such as ports and harbours, jetties, quays, wharves, erosion control measures, breakwaters, pipelines, navigational safety facilities and the like".
7.	DISTRIBUTION STATEMENT	NOT FOR CIRCULATION
8.	PROJECT PROPONENT	The Executive Engineer, Harbour Engineering Division, Kasaragod - 671 121

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HTL, LTL, AND CRZ FOR THE PROJECT AREA PROPOSED FOR THE CONSTRUCTION OF AJANUR FISHING HARBOUR IN AJANUR GRAMA PANCHAYAT, KASARAGOD DISTRICT, KERALA

1.0 Introduction

The Harbour Engineering Department, Kasaragod Division, Government of Kerala, proposes to construct a Fishing Harbour at the Ajanur seacoast, located south of the Chithari River mouth in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod. The Executive Engineer, Harbour Engineering Division, Kasaragod, requested National Centre for Earth Science Studies (NCESS), Ministry of Earth Sciences, Government of India, Thiruvananthapuram, an agency authorised by the Government of India to delineate HTL and LTL, to provide CRZ Map and Status Report to facilitate CRZ clearance for the proposed construction of Fishing Harbour at Ajanur near Chithari River in Ajanur Grama Panchayat, Kasaragod District, Kerala. According to the approved CZMP as per CRZ Notification 2019, part of the project area (other part of the project area located in the Lakshadweep Sea and Poramboke land) is located in Survey Numbers 176 and 187 in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod District, Kerala. The proposed harbor construction site is within the Coastal Regulation Zone (CRZ) of Lakshadweep Sea, and Chithari River as per the Coastal Zone Management Plan (CZMP) of Kerala prepared as per CRZ Notification, 2019 and approved in 2024 (hereinafter referred to as CZMP of Kerala).

As outlined in the Detailed Project Report (DPR) provided by the project proponent, Ajanur is a well-known fishing village located in the Kasaragod District. A variety of fishing crafts operate from this area. Both the fishermen and the local fishery industry are consistently advocating for further development of the region. In addition to requests for the construction of a new fishing harbor, there are ongoing demands to make the Chithari River mouth permanent and to prevent the formation of sandbars at its entrance. The mouth of the Chithari River is migratory in nature and often becomes completely closed during the summer months. This closure leads to flash floods in the coastal areas where the estuary drains into the sea, resulting in disaster for people living upstream. The situation worsens due to the river's catchment area being densely populated with urban developments. The river discharge is hindered by the sandbars formed by the coastal marine processes, which necessitates annual human intervention to reopen the river mouth before the monsoon season. Additionally, the

migratory nature of the river mouth has shifted significantly to the south in recent years, causing damage to the auction halls and other infrastructure established for fisheries in the area.

The NCESS has taken up the preparation of CRZ Maps and Status Report by demarcating the High Tide Line (HTL), Low Tide Line (LTL), and Coastal Regulation Zone (CRZ) for the proposed construction of Ajanur Fishing Harbour in Ajanur Grama Panchayat, Kasaragod District. The CRZ Maps and Status Report are prepared based on the field investigation carried out during November 2022, March 2024, and February 2025. The proposed construction site and its vicinity are encompassed in Map No. KL - 78 (Sheet No. D 43 V 3/SW) of the CZMP of Kerala prepared as per the CRZ Notification, 2019 and approved in 2024. In the CZMP, the HTL, LTL and CRZ are demarcated in 1:25000 scale. However, the Ministry of Environment Forests and Climate Change (MoEF&CC), Govt. of India has directed the project proponents to get CRZ Maps prepared in cadastral scale for the project area so that more details are made available. The CRZ Notification 2019 directs to prepare local level CZM/CRZ maps onto cadastral base in 1:3960 or nearest scale to facilitate implementation of Coastal Zone Management Plans. Accordingly, the CRZ Map is prepared in cadastral scale (1:4000) based on field investigations.

The demarcation of the HTL and LTL for the project area has been carried out following the guidelines as per the CRZ Notification 2019. The Coastal Zone Management Plan of Kerala has also been referred for accomplishing the work. The site being on the seacoast of the Lakshadweep Sea and Chithari River, the development activities regulated as provided in the Coastal Regulation Zone (CRZ) Notification, 2019, are applicable for the proposed construction of Ajanur Fishing Harbour.

2.0 Proposed Project Activities

As per the project layout and DPR provided by the project proponent, the proposed construction of Ajanur Fishing Harbour consists of a north breakwater of 1150 m in length, and south breakwater of 425 m length, a north training wall of 435 m in length, a wharf, auction hall, parking area, toilet, water supply arrangements, canteen/gearshed/shop/rest room, gate & gatehouse, internal road, boat building & repairing yard, reclamation bund, packing container storage space, office cum surveillance camera room, ETP, rainwater harvesting, compound wall, approach road, basin dredging, berthing wharf and dredging near training wall. The

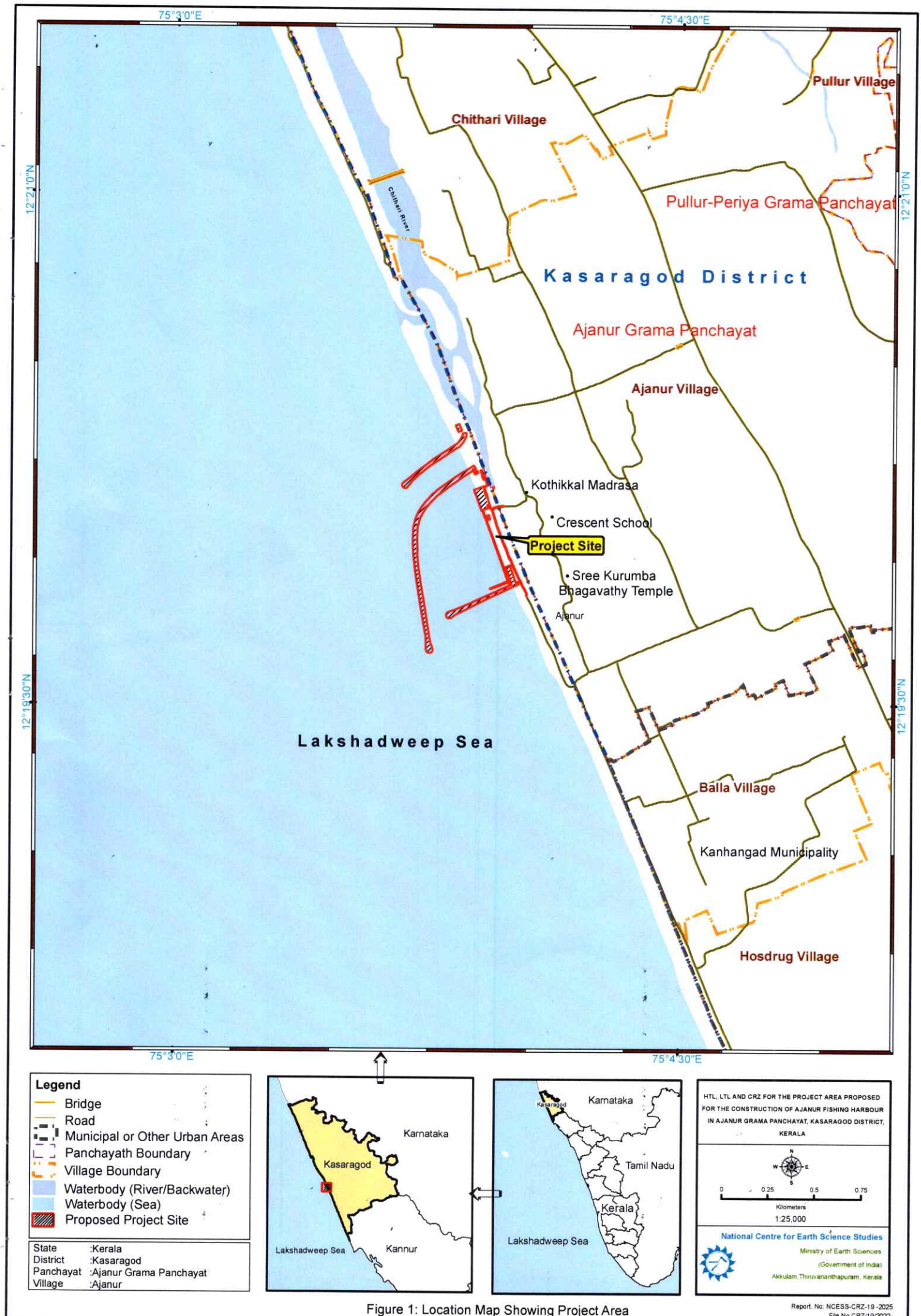


Figure 1: Location Map Showing Project Area

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project site also includes the existing buildings of the fish landing centre, which comprises the net mending building, an auction hall, and a toilet block. The total estimated cost of the project, including all components, is Rs. 20,000 lakhs.

3.0 Location

The proposed site for the Ajanur Fishing Harbour is situated along the Ajanur seacoast, south of the Chithari River mouth, in Ajanur Village, within the Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod. Ajanur is a coastal village bordered on the west by the Lakshadweep Sea and the Chithari River. To the north and south, it is bordered by Chithari and Balla Villages, respectively. According to the approved CZMP (as per CRZ Notification 2019), part of the project site is located in Survey Numbers 176 and 187 in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod District, Kerala. The majority of the proposed project site is situated on the Lakshadweep Sea and Poramboke land on the outskirts of Ajannur Village. The northern part of the proposed project site is located on the Chithari River spit (sandbar), while the southern part of the site, along the seacoast, is protected by seawalls. Along the coastline, dense settlements are observed in the vicinity of the project area, especially the southern side of the project site, and a wide sandy beach is observed on the seaward side of the Fish Landing Centre Road. The proposed project area is directly accessible via the Ajanur Fish Landing Centre Coastal Road. Additionally, it can be reached through Crescent Road, which runs parallel to the seacoast and connects with Ajanur Fish Landing Centre Coastal Road (see Fig. 1, Location Map). The project area is located between 12°19'38.831"N to 12°20'19.405"N Latitude and 75°3'40.226"E to 75°4'2.726"E Longitude.

4.0 Objectives

The objectives of the study are:

- Delineation of the HTL, LTL, and other CRZ lines in the cadastral map (1:4000 scale) of the project area and its vicinity for the proposed construction of Ajanur Fishing Harbour in Ajanur Grama Panchayat, Kasaragod District, Kerala.
- Categorization of Coastal Regulation Zone (CRZ) for the project area and its vicinity with respect to the approved CZMP of Kerala State and CRZ Notification, 2019.
- Preparation of the CRZ Categories Map showing a 7 Km radius area around the project site on 1:25000 scale.

- Preparation of CRZ Map and Status Report based on field observations, approved CZMP of Kerala, available spatial data, and the guidelines provided in the CRZ Notifications 2019.

5.0 Coastal Regulation Zone (CRZ)

All developmental activities in the CRZ are regulated through the CRZ Notification 2019. The Government of India Notification [S.O. 37 (E) dated 18.01.2019] under Section 3(1) and Section 3(2) (v) of the Environment (Protection) Act, 1986 and Rule 5(3) (d) of Environment (Protection) Rules, 1986 has redefined the CRZ. Accordingly, the CRZ has been declared as 'the coastal stretches of the country and the water area up to its territorial water limit excluding the islands of Andaman and Nicobar and Lakshadweep and the marine areas surrounding these islands up to its territorial limit' (CRZ Notification, 2019). The CRZ Consists of:

1. Land area from the High Tide Line (HTL) to 500 m on the landward side along the seafront.
2. Land area between the HTL to 50 m or width of the creek whichever is less on the landward side along the tidal-influenced water bodies that are connected to the sea and the distance up to which development along such tidal-influenced water bodies is to be regulated shall be governed by the distance up to which tidal effects are experienced which is determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year and distance up to which tidal effects are experienced should be clearly identified and demarcated accordingly in the Coastal Zone Management Plans (CZMPs). Tidal influenced water bodies mean the water bodies influenced by tidal effects from the sea in the bays, estuaries, rivers, creeks, backwaters, lagoons, ponds that are connected to the sea.
3. The ecologically sensitive area and the geomorphological features which play a role in maintaining the integrity of the coast.
4. Land area between High Tide Line (HTL) and Low Tide Line (LTL), which will be termed as the Intertidal Zone (ITZ).
5. Water and the bed area between the LTL to the territorial water limit (12 Nm) in the case of sea (CRZ IVA) and the water and the bed area between LTL at the bank to the LTL on the opposite side of the bank, of tidal influenced water bodies (CRZ IVB).

6. Land area falling between the hazard line and 500 m from HTL on the landward side, in case of seafront and between the hazard line and 50 m line in case of tidal influenced water body. The word' hazard line' denotes the line demarcated by Ministry of Environment Forests and Climate Change (MoEF&CC) through the Survey of India (SoI) taking into account tides, waves, sea level rise and shoreline changes.

For the purpose of conserving and protecting the coastal areas and marine waters, the CRZ Notification 2019 categorizes Coastal Regulation Zones as CRZ I (CRZ IA and CRZ IB), CRZ II, CRZ III (CRZ IIIA and CRZ IIIB), and CRZ IV (CRZ IVA and CRZ IVB) based on whether the area is ecologically sensitive, developed, undeveloped, or water body and its bed. Ecologically sensitive and important areas are CRZ IA, and the intertidal zone is CRZ IB. Major CRZ IA categories include mangroves, corals and coral reefs, sand dunes, Biologically active mudflats, National Parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas under the provisions of Wildlife (Protection) Act, 1972 (53 of 1972), Forest (Conservation) Act, 1980 (69 of 1980) or Environment (Protection) Act, 1986 (29 of 1986) including Biosphere Reserves salt marshes, turtle nesting grounds, horseshoe crab habitats, sea grass beds, nesting ground of birds, areas or structures of archaeological importance and heritage sites and Eco-Sensitive Zone [F.No.12/1/2019-IA.III (E-122245) dated: 26th October, 2021]. In case the mangrove area is more than 1000 m^2, a buffer of 50 m along the mangroves shall be provided and such area shall also constitute CRZ IA. Mangroves in Government land shall be protected based on a detailed plan to be prepared by the concerned State Governments or Union territory administrations and in case the mangrove area is more than 1000 m^2 a buffer of 50 m along the periphery of mangrove area shall be provided. Mangroves in private land will not require a buffer zone, but in such areas, mangroves shall be protected. CRZ IB is the area between Low Tide Line and High Tide Line (Inter Tidal Zone). The developed land areas up to or close to the shoreline, within the existing municipal limits or in other legally designated urban areas where the built-up area is more than 50% are categorized as CRZ II. Rural/undeveloped land areas that are relatively undisturbed belong to CRZ III. Densely populated CRZ-III areas, where the population density is more than 2161 per square kilometer as per 2011 census base, shall be designated as CRZ IIIA and in CRZ IIIA, area up to 50 m from the HTL on the landward side shall be earmarked as the 'No development Zone (NDZ)'. All other CRZ-III areas with population density of less than 2161 per square kilometer, as per

2011 census base, shall be designated as CRZ-III B and in CRZ-III B, the area up to 200 m from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)'. The water area and the sea bed area between the Low Tide Line up to 12 nautical miles on the seaward side shall constitute CRZ-IV A. CRZ-IV B areas shall include the water area and the bed area between LTL at the bank of the tidal influenced water body to the LTL on the opposite side of the bank, extending from the mouth of the water body at the sea up to the influence of tide, i.e., salinity of five parts per thousand (ppt) during the driest season of the year.

As per the Amendment to the CRZ Notification 2019, gazette notification no. S.O. 1422 (e) dated 1st May, 2020 & no. S.O. 4886 (e) dated 26th November 2021, In case there exists a bund or a sluice gate constructed in the past, prior to the date of notification issued vide S.O. 114 (E) dated 19th February 1991, the HTL shall be restricted up to the line long along the bund or the sluice gate and in such a case, area under mangroves arising due to saline water ingress beyond the bund or sluice gate shall be classified as CRZ-IA irrespective of the extent of the area beyond the bund or sluice gate. Such areas under mangroves shall be protected and shall not be diverted for any developmental activities.

The CRZ Notification of 2019 has also defined Critical Vulnerable Coastal Areas (CVCA), which includes Sundarbans in West Bengal and other identified ecologically sensitive areas as under Environment (Protection) Act, 1986 in which Vembanad in Kerala is also included. The Ministry of Environment & Forests, Govt. of India has issued the CRZ Notification on 18th January 2019 (CRZ Notification 2019) in supersession of CRZ Notification 2011 except as respects things done or omitted to be done before such supersession.

All the inland islands in the coastal backwaters and islands along the mainland coast shall be covered under the notification, 2019 and the CRZ of 20 m from the HTL on the landward side shall uniformly apply to such islands. The islands demarcated in Kerala as mainland coast islands and inland islands in the coastal backwaters need to have Integrated Island Management Plans (IIMPs), as applicable to smaller islands in Lakshadweep and Andaman & Nicobar, as per Island Protection Zone Notification, 2011 number S.O. 20(E), dated the 6th January, 2011 to be formulated by the Kerala State. The islands are buffered with 50 m or width of the creek whichever is less till the IIMPs are framed and 20m CRZ line landward of HTL will be considered only after IIMP is implemented.

6.0 CRZ for the State of Kerala

The CRZ Notification 2019 is published on 18th January 2019, issued in supersession of CRZ Notification 2011 (except as respects things done or omitted to be done before such supersession). Coastal Zone Management Plan of Kerala prepared as per CRZ Notification 2019 was approved by Ministry of Environment and Forest and Climate Change (MoEF&CC) on 16th October 2024 (F. No. IA3-12/7/2021-IA.III (E-153017) dated 16-10-2024). The approved CZMP has areas covered under CRZ-I (CRZ IA & CRZ IB), CRZ II, CRZ III (CRZ IIIA & CRZ IIIB) and CRZ IV (CRZ IVA & CRZ IVB) categories.

According to the provision in CRZ Notification 2019 (Amendment to the CRZ Notification 2019, gazette notification no. S.O. 1422 (e) dated 1st May 2020 & no. S.O. 4886 (e) dated 26th November 2021), the HTL along some stretches of Kerala shall be restricted up to the bunds or sluice gates constructed in the past and prior to the date of notification issued vide S.O. 114 (E) dated 19th February 1991. The areas under mangroves arising due to saline water ingress beyond the bund or sluice gate shall be classified as CRZ-IA, such areas under mangroves shall be protected and shall not be diverted for any developmental activities.

The 45th meeting of the National Coastal Zone Management Authority (NCZMA) held on 01.09.2022, has recommended Category I Coastal Grama Panchayats in the State of Kerala notified before the issue of CRZ Notification, 2019 be considered as 'Other Legally Designated Urban Areas' as per the CRZ Notification, 2019 i.e., existing as on the date of issue of CRZ Notification, 2019. These category-I Panchayats (66 Grama Panchayats) met the criteria of built-up area and developmental infrastructure be considered for classification as falling under CRZ II area (Ref: No:08/A2/2019/KCZMA dated 03.09.2022). However, the areas specified by the Department of Atomic Energy in the afore mentioned coastal Panchayats shall not be categorized as CRZ II and shall be classified as CRZ III A or CRZ III B as per the norms and such areas shall be contiguous in nature" (Ref no. Office Memorandum File No. J-17011/18/96- IA.III (Vol.VI) dated 02.09.2022 from Ministry of Environment Forest and Climate Change).

The CRZ Notification 2019 categorizes areas that are ecologically sensitive identified based on the geomorphological features (which play a role in the maintaining the integrity of the coast) such as mangroves, turtle nesting sites, archaeologically important and heritage sites

etc., as CRZ IA. Mangroves shall be protected, and if the mangrove area is more than 1000 m2, a buffer zone of 50 m along the periphery of the mangrove area shall be provided for government lands. The Intertidal Zone is the area between the Low Tide Line and the High Tide Line, constituting CRZ IB. As per the CZMP of Kerala based on CRZ Notification 2019, the existing Municipalities, Corporations, and legally designated urban areas (except those categorized as CRZ I and CRZ IV) are categorized as CRZ II, and the rest of the relatively undisturbed Grama Panchayats have been categorized as CRZ III. CRZ III has been further classified in to CRZ IIIA and CRZ IIIB based on population density. Densely populated CRZ-III areas, where the population density is more than 2161 per square kilometer as per 2011 census base, have been designated as CRZ IIIA and in CRZ IIIA, area up to 50 m from the HTL on the landward side shall be earmarked as the 'No development Zone (NDZ)'. All other CRZ-III areas with population density of less than 2161 per square kilometer, as per 2011 census base, have been designated as CRZ-IIIB and in CRZ-IIIB, the area up to 200 m from the HTL on the landward side have been earmarked as the 'No Development Zone (NDZ)'. CRZ applies to the land area from HTL to 50 m or width of the creek, whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea. CRZ IV is water and the bed area between the LTL and the territorial water limit (12 Nm) in the case of sea (CRZ IVA) and the water and the bed area between LTL at the bank and the LTL on the opposite side of the bank of tidal influenced water bodies (CRZ IVB).

The 'Hazard Line' has been demarcated in the approved CZMP of Kerala based on CRZ Notification, 2019. In view of the unique coastal systems of backwater islands and islands along the mainland coast, along with space limitations in such coastal stretches, CRZ of 20 m from the HTL on the landward side shall uniformly apply to such islands. However, it will be implemented only after the approval of IIMP of the particular Island.

The CRZ Notifications of 2019 has also defined Vembanad Backwaters as one among the Critically Vulnerable Coastal Areas (CVCA) for which development activities need to be within the framework of an approved ICZMP. The notified port limits are incorporated in the approved CZMP of Kerala as per CRZ Notification 2019.

7.0 Approach and Methodology

Coastal geomorphology and ecosystems of the project area have been studied-using Survey of India Toposheets and high-resolution Satellite images. Topographic sheets and Satellite images came in handy in capturing diverse coastal ecosystems in the project area and its vicinity as baseline information prior to field investigations. The approved CZMP of Kerala was referred to ascertain the applicability of site-specific coastal regulation criteria.

Cadastral maps in 1:3960 scale with survey plot information have been used as the base map on which the project layout has to be superimposed. A field investigation was conducted to capture the ground details. Collateral cadastral features- unambiguous locations identifiable both on the ground and in the cadastral maps, such as survey plot boundary junctions, survey stones, canal crossing, bridges, culverts, etc., are used as Ground Control Points (GCP). Cadastral maps were georeferenced with precise geo-coordinates measured using GPS at pre-identified GCPs to collate spatial data onto the GIS platform. Planimetric standards were met to maintain the accuracy of measurements. UTM projection on to WGS 84 datum has been adopted for appropriate GIS composition. Being plotted in cadastral maps of 1:4000 scale, the HTL and CRZ boundaries are locatable in the field with respect to survey plots with adequate accuracy.

Key elements of the general approach followed in the study are:

- To carry out field investigation for delineating HTL and LTL on the cadastral base maps of the project area and its vicinity based on CRZ Notification 2019.
- To verify the approved CZMP of Kerala and identify CRZ areas.
- To gather information on the status of ecosystems (such as mangroves, tidal flats, sand dunes, etc.) in the project area and its vicinity along the seacoast of Lakshadweep Sea.
- To observe and record geomorphologic signatures for identifying HTL and map the distance to HTL with respect to concerned survey plots.
- To prepare the CRZ map delineating the HTL, LTL, and CRZ in cadastral scale, enabling to locate the HTL and other regulation lines precisely in the field.

- To prepare the CRZ Map and Status Report based on the field investigation, project layout, approved CZMP of Kerala, and CRZ Notification 2019.

8.0 Data Source

Different sets of data were used to compile the final map and prepare the CRZ report. The principal data sources are listed below:

i. Survey of India Toposheets

ii. High-resolution satellite imageries

iii. Timeline Google images of the area

iv. Cadastral maps

v. Approved CZMP of Kerala State as per CRZ Notification, 2019

vi. Hydrographic charts of the Naval Hydrographic Office

vii. Field mapping

9.0 Influence of Tidal Action

Coastal Zone Regulations are applicable to the seacoast water and bed area up to territorial water limit (12 Nautical miles) and banks and water and bed area of waterbodies influenced by tidal action. Therefore, tidal range is an important parameter that decides the extent of CRZ along rivers and backwaters. It also determines the reach of the 'highest water line during the spring tide'. Kasaragod coast is of micro-tidal nature. Tidal heights with respect to Chart Datum (CD) pertaining to Kasaragod, as provided by the Navel Hydrographic Office, Dehradun (NHO 1977), are given below.

Table 1. Tidal heights with respect to Chart Datum (CD) pertaining to Kasaragod.

Tide condition at Kasaragod	Water Level Height w.r.t. CD (m)
Mean Higher High Water	1.43
Mean Lower High Water	1.29

Mean Sea Level	0.98
Mean Higher Low Water	0.87
Mean Lower Low Water	0.39

As can be seen from the above table, the Mean Lower Low Water and Mean Higher High Water are 0.39 m and 1.43 m respectively. The distance up to which development along bays, estuaries, creeks and backwaters is regulated under CRZ depends on the landward extent of tidal influence. The distance up to which tidal influence is experienced is fixed based on salinity concentration of 5 parts per thousand measured during the driest period of the year (CRZ Notifications 2011). The same for the Chithari River, a tidal river, was inferred from the Coastal Zone Management Plan of Kerala. The Chithari River debouches into the Lakshadweep Sea at Ajanur, which is located immediately north of the project site.

10.0 Field Investigation

The MoEF&CC guidelines in CRZ Notification, 2019 stipulate that the HTL/LTL be identified based on coastal geomorphologic signatures in the field/satellite imageries/aerial photographs. Therefore, delineation of the HTL and LTL and identification of Coastal Regulation Zones for the project area and its vicinity were carried out based on geomorphic and other relevant signatures such as landward monsoonal berm crest, rocks, headlands, cliffs, seawalls or revetments or embankments, permanent vegetation line, ecologically sensitive areas (mangroves), intertidal areas and developed or undeveloped areas.

Field investigations were carried out in November 2022, March 2024, and February 2025. A DISTOPRO laser meter was used for precision distance measurements. Trimble- handheld GNSS receiver of model 'TDC 600' and Brunton compass were used for obtaining the ground positions. Cadastral/Village map of 1:5000 scale of Ajanur Village pertaining to the project site and its vicinity, procured from the Survey Department was used as the base map. HTL and LTL, known points, roads positions and bridges were marked using line/point features captured using high precision GNSS receiver. Photos depicting the morphology and the landuse pattern of the project area, and its vicinity were taken. An appraisal of existing landuse/landform in the project area was carried out to identify the existence of any ecologically sensitive areas and

areas or structures of archaeological importance/heritage sites to be categorized as CRZ IA. The CZMP of the Kerala, the CRZ Notification 2019 and the plan of the site given by the project proponent have been referred for CRZ categorization in addition to a detailed appraisal of existing landuse pattern in the project area.

11.0 Geomorphology and Landuse of the Project Area and its Vicinity

A detailed appraisal of the ecosystems and existing landuse in the project area and its vicinity were carried out to help the categorization of the regulation zones pertaining to sensitive and important coastal ecosystems. Apart from the field investigation, Survey of India topographic maps and very high-resolution satellite imageries of the area were also used for the same wherever required. The project area for the proposed construction of Fishing Harbour at the Ajanur seacoast, is located south of the Chithari River mouth in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod. Ajanur is a coastal village bordered on the west by the Lakshadweep Sea and the Chithari River. The northern part of the proposed project site is located on the Chithari River spit (sandbar), while the southern part of the site, along the seacoast, is protected by seawalls in some stretches. During the field survey, it was observed that the northern side of the project site features a 120 m wide sandbar formation, the middle section has a 25 m wide beach, and the southern side contains a 40 m wide beach.

The Chithari basin encompasses the watersheds of the Kalnad, Bakel, and Chithari Rivers. The Chithari River is formed by several rivulets that originate from Cherambe, Tayakolam, and Pullur. These rivulets flow together to create a backwater before emptying into the Lakshadweep Sea. The coastal morphology of the Chithari River mouth is highly undulating in nature. The migration of the river mouth and the formation of the sandbar occur seasonally. During the summer, the river mouth completely closes, which adversely affects the fishing community and residents living along the banks of the Chithari River. Therefore, annual human intervention is necessary to reopen the river mouth before the monsoon season. The proposed construction of Ajanur Fishing Harbour may change the coastal morphology along the shoreline and river mouth.

Along the coastline, dense settlements are observed in the vicinity of the project area, especially the southern side of the project site, and a sandy beach is observed on the seaward side of the Fish Landing Centre Road. The proposed project area is directly accessible via the Ajanur Fish

Landing Centre Coastal Road. Additionally, it can be reached through Crescent Road, which runs parallel to the seacoast and connects with Ajanur Fish Landing Centre Coastal Road. The Kasaragod district can be divided into three distinct physiographical units: the coastal plains, the midlands, and the eastern highland regions. The coastal plains form the lowland areas adjacent to the Lakshadweep Sea. Topographically, the project area is a plain land and mixed tree crops with settlements dominate the landuse pattern in this area. The soil nature observed is generally coastal alluvial soil. The existing structures, such as the net mending building, auction hall, and toilet block, are located within the project site. Sparse mangroves are found along the Chithari Riverbank at the northeastern boundary of the project site.

12.0 Identification of HTL, LTL and CRZ

HTL is the line on the land, up to which the highest water line reaches during the spring tide. The sea level thus formed due to the combined effect of spring tide and wave set up gives the line of maximum reach of water on the land. The conventional definition of the lowest low water level and the resultant low water line during spring tide has been taken as the Low Tide Line (LTL). The HTL/LTL has been identified based on the coastal geomorphologic signatures in the field and also by referring to satellite imageries/aerial photographs following the guidelines of MoEF&CC. The landward of monsoonal berms, embankments, cliffs, rocks, seawall, permanent vegetation line, intertidal zones and mangroves have been considered for identifying the HTL. Once the HTL/LTL is identified, the distances to these are measured with respect to the survey plot boundaries identified in the field. An appraisal of existing landuse/landform in the project area is carried out to determine the ecologically sensitive and important areas to be categorized as CRZ IA present in the study area. The approved CZMP of Kerala has also been referred for CRZ categorization.

13.0 HTL/LTL and CRZ for the Project Area

The project area for the proposed construction of Ajanur Fishing Harbour is located within the Coastal Regulation Zone of the Lakshadweep Sea and Chithari River. The proposed site for the Ajanur Fishing Harbour is situated along the Ajanur seacoast, south of the Chithari River mouth, near the existing Ajanur Fish Landing Centre. The proposed project site has a High Tide Line on the seaside and the riverside. The seaward side of the High Tide Line is along the line of permanent vegetation, second monsoonal berms, the landward end of the concrete

embankment, and the landward end of the seawall. There are no adequately constructed embankments along the Chithari Riverbanks in the project area or its vicinity; only earthen embankments and vegetation are to be seen. The river side of the High Tide Line at the project site is along the line of permanent vegetation/earthen embankment.

The LTL is the lowest low water level resulting from the lowest spring tide. The Low Tide Line, seaward of the foreshore, is inferred from the topographical sheet and field measurements using GPS. LTL is also demarcated along the banks of Chithari River. Along the coastline, dense settlements are observed in the vicinity of the project area, especially the southern side of the project site, and a sandy beach is observed on the seaward side of the Fish Landing Centre Road. During the field survey, it was observed that the northern side of the project site features a 120 m wide sandbar formation, the middle section has a 25 m wide beach, and the southern side contains a 40 m wide beach. The project site is directly accessible via the Ajanur Fish Landing Centre Coastal Road.

According to the approved CZMP (as per CRZ Notification, 2019) map, ecologically sensitive areas such as mangroves are not depicted in the project site or close vicinity. However, during the field survey, mangrove patches were observed within the project area and its vicinity along Chithari Riverbanks, which have been incorporated into the CRZ map. Other ecologically sensitive areas such as turtle nesting grounds, areas or structures of archaeological importance and heritage sites, etc., which are categorised as CRZ IA, are not found in the project area or in its close proximity.

The intertidal area found along the seacoast and Chithari Riverbanks between the High Tide Line and Low Tide Line is CRZ IB. Along the seacoast, the CRZ extends landward from the HTL up to a distance of 500 m. The water and bed area from the LTL up to the territorial water limit (12 Nautical miles) in the case of seacoast is CRZ IVA. The water and the bed area of the river located to the north and east of the project site are CRZ IVB. According to the approved Coastal Zone Management Plan (CZMP) of Kerala as per CRZ Notification 2019, part of the project area is located in Ajanur Grama Panchayat (Ajanur Village), which is a category-1 legally designated Urban Area; hence, it is categorized as CRZ II. The Ajanur Grama Panchayat is the coastal grama panchayat in the state of Kerala, which is considered as 'other legally designated Urban Areas' as per CRZ Notification 2019. This category-1 panchayat (66 Grama

Panchayats) met the criteria of built-up area and developmental infrastructure to be considered for classification as falling under CRZ II area (Ref: 08/A2/2019/KCZMA dated 03,09.2022).

The proposed project activities, such as Northern Breakwater, Southern Breakwater, North Training Wall, Auction Hall, Internal Road, and Office Cum Surveillance Camera Room, fall within the CRZ IB (Intertidal Zone) and CRZ IVA (Lakshadweep Sea) categories. The proposed Parking Area falls within the CRZ IB (Intertidal Zone), CRZ II, and CRZ IVA (Lakshadweep Sea) categories. The proposed project activities such as Rainwater Harvesting, Canteen & Gearshed & Shop & Rest Room and Toilet fall in CRZ IB (Intertidal Zone) and CRZ IVB (Chithari River) categories. The proposed Approach Road and proposed Packing Container Storage Space fall in the CRZ IB (Intertidal Zone) & CRZ II categories. The proposed Boat Building and Repairing Yard, proposed ETP and Proposed Water Supply Arrangements fall within the CRZ IB category. The proposed Gate & Gate House falls in the CRZ II category, and the proposed Berthing Wharf, the proposed Wharf, and the proposed Reclamation Bund fall in the CRZ IVA (Lakshadweep Sea) category. The proposed Compound Wall falls in CRZ IA (Mangroves), CRZ IB (Intertidal Zone) and CRZ II categories. The existing FLC Buildings fall within the CRZ IB (Intertidal Zone) and CRZ II categories. The length (in meters) and area (in square meters) of the proposed project activities falling under the CRZ categories based on approved CZMP (as per CRZ Notification, 2019), and field surveys are given in Table 2 and Table 3, respectively.

Table 2. The length (m) of the proposed project activities under CRZ categories

Sl. No.	Proposed project Activities (as given by the project proponent)	Project activities under CRZ categories (length in meters)				
		CRZ IA (Mangroves*)	CRZ IB (Intertidal Zone)	CRZ II	CRZ IVA (Lakshadweep Sea)	CRZ IVB (Chithari River)
1	Proposed Compound Wall	16.48	187.68	719.08	-	-
2	Proposed Reclamation Bund	-	-	-	749.14	-

* Mangrove (CRZ IA) Observed during the Field visit

Table 3. The area (sqm) of the proposed project activities under CRZ categories

Sl. No.	Proposed project Activities (as given by the project proponent)	Project activities under CRZ categories (area in square meters)			
		CRZ IB (Intertidal Zone)	CRZ II	CRZ IVA (Lakshadweep Sea)	CRZ IVB (Chithari River)
1	Proposed Northern and Southern Breakwater	1345.67	-	32606.60	-
2	Proposed North Training Wall	1768.73	-	7660.61	-
3	Proposed Auction Hall	2536.18	-	755.80	-
4	Proposed Internal Road	29.91	-	1751.28	-
5	Proposed Office Cum Surveillance Camera Room	331.12	-	0.45	-
6	Proposed Parking Area	3127.00	47.75	765.03	-
7	Proposed Rainwater Harvesting	5.56	-	-	9.70
8	Proposed Canteen, Gearshed, Shop and Rest Room	17.30	-	-	79.53
9	Proposed Toilet	8.87	-	-	5.37
10	Proposed Approach Road	45.82	3315.28	-	-
11	Proposed Packing Container Storage Space	657.60	262.62	-	-
12	Proposed Boat Building and Repair Yard	791.16	-	-	-
13	Proposed ETP	259.03	-	-	-
14	Proposed Water Supply Arrangement	257.96	-	-	-
15	Proposed Gate and Gate House		11.32	-	-
16	Proposed Berthing Wharf	-	-	517.15	-
17	Proposed Wharf	-	-	854.41	-

Footprints of a few existing buildings in the vicinity of the project site is demarcated in the CRZ Map. The project layout with the proposed construction as provided by the project proponent is superimposed on the CRZ Map. The HTL/LTL and CRZ status of the project area have been provided in the CRZ map (Figure 2). The CRZ categories for the 7 km radius area around the project area are depicted in Figure 3.

14.0 Summary

- The CRZ Map and Status Report are prepared based on the field investigation and the CRZ Notification, 2019.

- The High Tide Line, Low Tide Line and Coastal Regulation Zone mapping for the proposed construction of the Fishing Harbour at Ajanur and its vicinity in Ajanur Village, within the Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod District, has been done on cadastral maps of 1:4000 scale.
- According to the approved CZMP (as per CRZ Notification 2019), part of the project site is located in Survey Numbers 176 and 187 in Ajanur Village, Ajanur Grama Panchayat, Hosdurg Taluk, Kasaragod District, Kerala. The majority of the proposed project site is situated on the Lakshadweep Sea and Poramboke land on the outskirts of Ajannur Village.
- As per the project layout and DPR provided by the project proponent, the proposed construction of Ajanur Fishing Harbour consists of a north breakwater of 1150 m in length, and south breakwater of 425 m length, a north training wall of 435 m in length, a wharf, auction hall, parking area, toilet, water supply arrangements, canteen/gearshed/shop/rest room, gate & gatehouse, internal road, boat building & repairing yard, reclamation bund, packing container storage space, office cum surveillance camera room, ETP, rainwater harvesting, compound wall, approach road, basin dredging, berthing wharf and dredging near training wall.
- The project site also includes the existing buildings of the fish landing centre, which comprises the net mending building, an auction hall, and a toilet block.
- As per the detailed project report provided by the project proponent, the total estimated cost of the project, including all components, is Rs. 20,000 lakhs.
- HTL, LTL and CRZ appearing in the approved CZMP of the project area have been incorporated in the CRZ Map.
- The HTL and LTL were demarcated by taking into consideration the geomorphic signatures that are discernible in the field.
- The seaward side of the High Tide Line at the project site is along the line of permanent vegetation, second monsoonal berms, the landward end of the concrete embankment, and the landward end of the seawall. The river side of the High Tide Line at the project site is along the line of permanent vegetation/earthen embankment.
- The northern part of the proposed project site is located on the Chithari River spit (sandbar), while the southern part of the site, along the seacoast, is protected by seawalls.

- Along the coastline, dense settlements are observed in the vicinity of the project area, especially the southern side of the project site, and a wide sandy beach is observed on the seaward side of the Fish Landing Centre Road.
- During the field survey, it was observed that the northern side of the project site features a 120 m wide sandbar formation, the middle section has a 25 m wide beach, and the southern side contains a 40 m wide beach.
- The proposed project area is directly accessible via the Ajanur Fish Landing Centre Coastal Road. Additionally, it can be reached through Crescent Road, which runs parallel to the seacoast and connects with Ajanur Fish Landing Centre Coastal Road
- The project area falls within the Coastal Regulation Zone of the Lakshadweep Sea and Chithari River and is part of Map No. KL - 78 (Sheet No. D 43 V 3/SW) of the CZMP of Kerala (approved in 2024) prepared as per the CRZ Notification, 2019.
- According to the approved CZMP (as per CRZ Notification, 2019) map, ecologically sensitive areas such as mangroves are not depicted in the project site or close vicinity. However, during the field survey, mangrove patches were observed within the project area and its vicinity along Chithari Riverbanks, which have been incorporated into the CRZ map.
- Other ecologically sensitive areas such as turtle nesting grounds, areas or structures of archaeological importance and heritage sites, etc., which are categorised as CRZ IA, are not found in the project area or in its close proximity.
- The intertidal area found along the seacoast and Chithari Riverbanks between the High Tide Line and Low Tide Line is CRZ IB (CRZ Notification 2019).
- The CRZ along the seacoast is 500 m landward of the HTL as per the CRZ Notification 2019.
- The water and bed area from the LTL up to the territorial water limit (12 Nautical miles) in the case of seacoast is CRZ IVA (CRZ Notification 2019).
- The water and the bed area between the LTLS on both banks of the river, located to the north and east of the project site, are CRZ IVB (CRZ Notification 2019).
- According to the approved Coastal Zone Management Plan (CZMP) of Kerala as per CRZ Notification 2019, part of the project area is located in Ajanur Grama Panchayat (Ajanur

Village), which is a category-1 legally designated Urban Area; hence, it is categorized as CRZ II.

- The proposed project activities fall within the CRZ IA (Mangroves), CRZ IB (Intertidal Zone), CRZ II, CRZ IVA (Lakshadweep Sea), and CRZ IVB (Chithari River) categories.
- The existing FLC Buildings fall within the CRZ IB (Intertidal Zone) and CRZ II categories.
- The Hazard Line as demarcated by MoEF&CC through Survey of India and provided in the approved CZMP of Kerala is superimposed in the CRZ Map (Figure 2).
- Footprints of a few existing buildings in the vicinity of the project area have been demarcated in the CRZ Map.
- Layout of the project area with the existing and proposed activities (as provided by the project proponent) is superimposed in the CRZ Map.
- The 7 km radius area CRZ Map around the project site has been prepared in 1:25,000 scale (Figure 3).

15.0 Conclusion

- According to the approved Coastal Zone Management Plan (CZMP) of Kerala as per CRZ Notification 2019, part of the project area is located in Ajanur Grama Panchayat (Ajanur Village), which is a category-1 legally designated Urban Area; hence, it is categorized as CRZ II. The majority of the proposed project site is situated on the Lakshadweep Sea and Poramboke land on the outskirts of Ajannur Village.
- The proposed project activities fall within the CRZ IA (Mangroves), CRZ IB (Intertidal Zone), CRZ II, CRZ IVA (Lakshadweep Sea), and CRZ IVB (Chithari River) categories. The existing FLC Buildings fall within the CRZ IB (Intertidal Zone) and CRZ II categories.
- According to the approved CZMP (as per CRZ Notification, 2019) map, ecologically sensitive areas such as mangroves are not depicted in the project site or close vicinity. However, during the field survey, mangrove patches were observed within the project area and its vicinity along Chithari Riverbanks, which have been incorporated into the CRZ map.
- As per CRZ Notification 2019, Paragraph 5.1.2, activities shall be regulated or permissible in CRZ IB areas as under Clause (i), ie. "land reclamation, bunding, etc. shall be permitted only for activities such as (Sub-clause (a)) foreshore facilities like ports, harbours, jetties,

wharves, quays, slipway, bridges, hover ports for coast guard, sea links, etc.," and Clause (ii) ie. "the activities related to waterfront or directly needing foreshore facilities such as ports and harbours, jetties, quays, wharves, erosion control measures, breakwaters, pipelines, lighthouses, navigational safety facilities, coastal police stations, Indian coast guard stations and the like".

- As per CRZ Notification 2019, Paragraph 5.2, Clause (i), the activities permitted in CRZ IB shall also be permissible in CRZ-II, as applicable.
- As per CRZ Notification 2019, Paragraph 5.4, activities shall be permitted and regulated in CRZ IV areas as under Clause (ii), ie. "land reclamation, bunding, etc. to be permitted only for activities such as (Sub-clause (a)) foreshore facilities like ports, harbours, jetties, wharves, quays, slipways, bridges, sea links and hover pots for the coast guard, etc., and Clause (iii) ie. "activities related to waterfront or directly needing foreshore facilities, such as ports and harbours, jetties, quays, wharves, erosion control measures, breakwaters, pipelines, navigational safety facilities and the like".

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PLATES

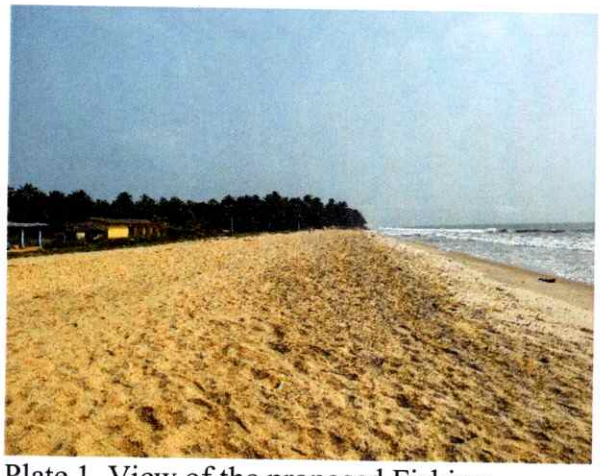


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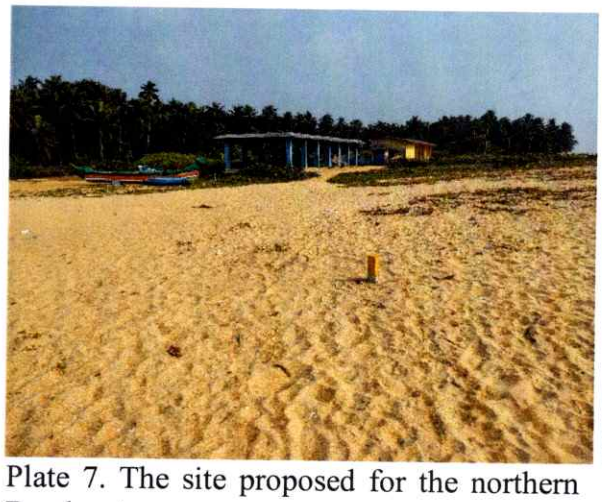


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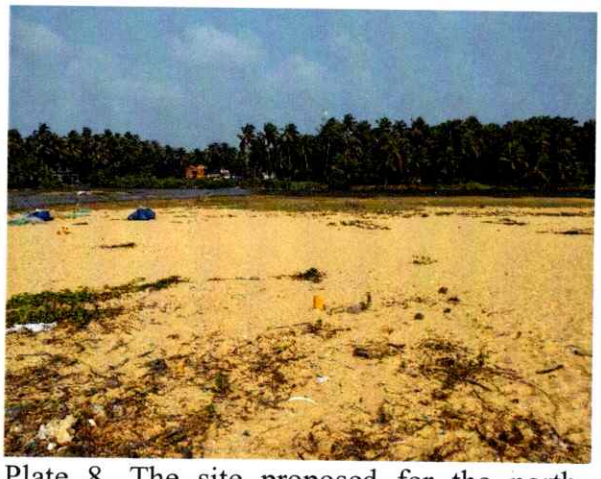


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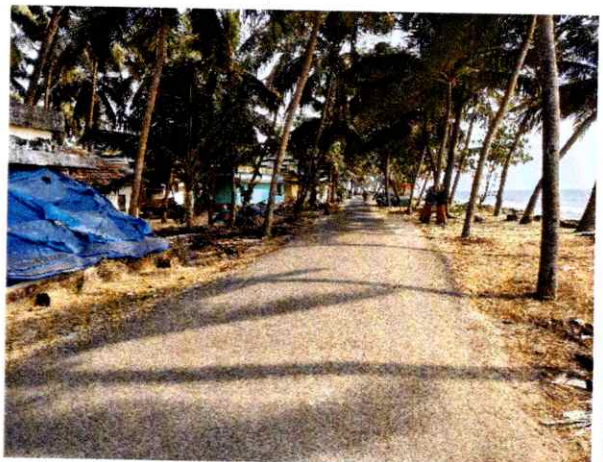


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GOVERNMENT OF INDIA
CENTRAL WATER AND POWER RESEARCH STATION
KHADAKWASLA, PUNE – 411 024



MATHEMATICAL MODELLING FOR COASTAL ENGINEERING

TECHNICAL NOTE
July 2022

ADDITIONAL MATHEMATICAL MODEL STUDIES FOR WAVE TRANQUILITY FOR REVISED LAYOUT OF FISHERIES HARBOUR AT AJANUR, KERALA

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Director

Technical Note **Date: July 2022**

Title: ADDITIONAL MATHEMATICAL MODE STUDIES FOR WAVE TRANQUILITY FOR REVISED LAYOUT OF FISHERIES HARBOUR AT AJANUR, KERALA

Officers Responsible for Conducting the Studies

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Central Water and Power Research Station, Pune, India

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Government of India
Ministry of Jal Shakti
Department of Water Resources, River Development & Ganga Rejuvenation
Central Water and Power Research Station
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Technical Note **Date: July 2022**

ADDITIONAL MATHEMATICAL MODE STUDIES FOR WAVE TRANQUILITY FOR REVISED LAYOUT OF FISHERIES HARBOUR AT AJANUR, KERALA

1. INTRODUCTION

Harbour Engineering Department, Government of Kerala has a proposal to develop a fishing harbour at Ajanur village situated about 15km south of Kasargod district at Latitude 12.33^0 N and Longitude 75.18^0 E in Kerala state (Figure 1) on the west coast of India. As per layout 4 suggested by CWPRS vide T.R. No. 5436, Nov 2016 (Ref.1) the harbour basin area comes out to be about 19ha. Considering the future expansion suggested by the Technical Sanction Committee of PMMSY schemes vide HED Letter No.D4/9509/06/CE dated 16-06-2022, Harbour Engineering Department proposed a revised layout of the Ajanur fishing harbor by increasing basin area of the harbor upto 26ha. The revised layout of the proposed harbour would consist of 1150m long north breakwater and 425m long south breakwater. Revised layout of the proposed harbor at Ajanur is shown in Figure 2. In the figure in order to control the shifting and functioning of Chittari River mouth, river training works at the mouth is also included. The river training works in the form of 435m long breakwater at north side of northern breakwater is proposed based on littoral drift studies carried out at CWPRS (Ref.2) which indicated that southward drift was predominant and littoral zone was estimated to be in the range of 250m from the coastline. Earlier, based on wave tranquility studies undertaken at CWPRS, Layout 4 having 1000m long northern breakwater and 375m southern breakwater was suggested for the proposed harbor at Ajanur. In order to increase the basin area of the proposed harbor at Ajanur, northern and southern breakwaters are extended upto 1150m and 425m respectively. In order to examine the tranquility in the harbor basin, model studies were again referred to CWPRS. The technical note contains details of wave tranquility studies for the revised layout with different alternatives of north breakwater length.

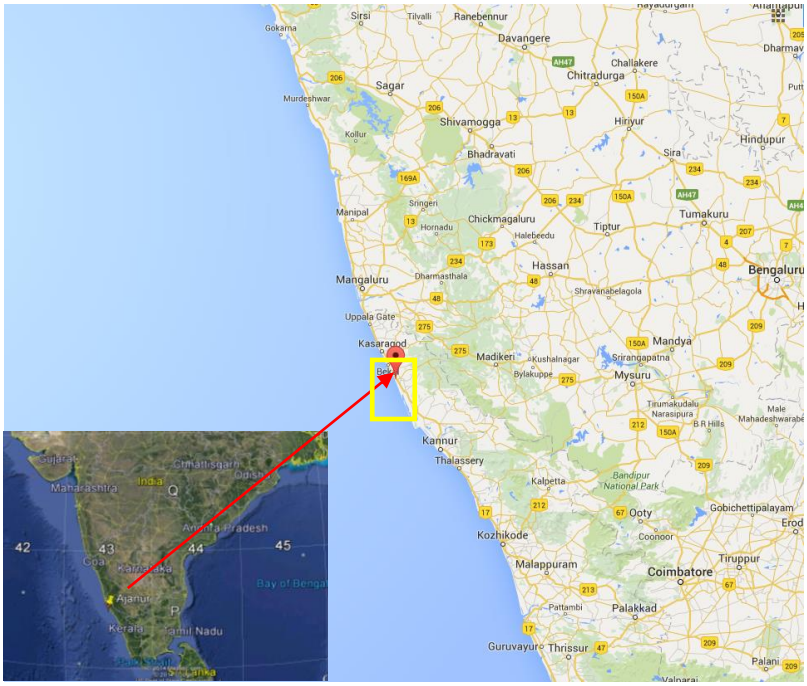


Figure 1 Index map of Ajanur site, Kerala

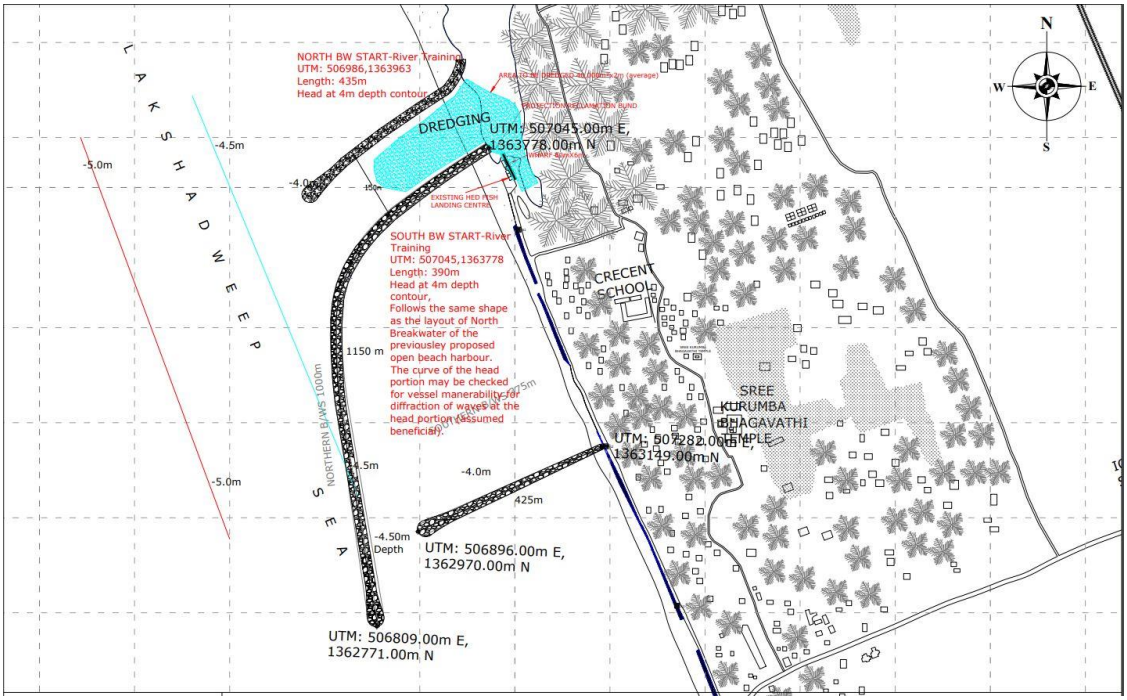


Figure 2 Revised layout of proposed harbor at Ajanur, Kerala

2. SCOPE OF STUDIES

Mathematical model studies for wave tranquility were carried out with the following scope:

1. Transformation of wave height and wave direction from deep water to 10m depth using MIKE 21 SW Model (Spectral Wave Model) carried out at CWPRS detailed in T.R. No. 5436, November 2016 (Ref.1).
2. Simulation of wave propagation to obtain wave height distribution in harbor basin using MIKE 21 BW model.

2.1 Tidal Data

The proposed site of development is in the south of Kasargod. Important tidal levels at Kasargod with respect to Chart Datum (As per Admiralty Chart No. 217 and 2029) are reported to be as under:

MHHW : 1.4m
MLHW : 1.3m
MSL : 1.0m
MHLW : 0.9m
MLLW : 0.4m

This indicates that the maximum tidal range in the study area is of the order of 1.0m. Tidal currents are generally parallel to the coastline and directed northward during flood as well as ebb tide with the maximum magnitude of the order of 0.4m/s (Littoral drift studies carried out at CWPRS T.R. No. 5357 of February 2016) (Ref.2).

3. MATHEMATICAL MODEL STUDIES

Mathematical model studies for examining the wave conditions in the proposed fishery harbor with revised layout were carried out by MIKE 21 BW model. The frequency distribution of wave heights from different directions at the inshore location in 10m depth is given in Table 1 to Table 4 Corresponding wave rose diagrams are presented in Figure 3 to Figure 6.

Table 1 Percentage occurrence of Wave height & direction at Ajanur for South-West monsoon (June-Sept)

Wave Height (m)	0.30	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	TOTAL
Direction										Calm %	3.03
180	0.39	0.98	0.20	0.20	0.00	0.00	0.00	0.00	0.00	0.00	1.76
202.5	0.59	1.08	2.74	1.08	0.20	0.00	0.00	0.00	0.00	0.00	5.67
225	0.49	1.17	2.93	2.54	0.68	0.20	0.00	0.00	0.00	0.00	8.01
247.5	0.49	2.15	4.20	2.74	2.05	2.64	0.00	0.00	0.00	0.00	14.27
270	2.15	5.18	11.53	12.12	12.61	5.87	1.37	0.00	0.00	0.00	50.83
292.5	0.68	6.55	5.08	3.71	0.39	0.00	0.00	0.00	0.00	0.00	16.42
TOTAL	4.79	17.11	26.69	22.39	15.93	8.70	1.37	0.00	0.00	0.00	100.0

Table 2 Percentage occurrence of Wave height & direction at Ajanur for North-East monsoon period (Oct-Jan)

Wave Height (m)	0.30	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	TOTAL
Direction										Calm %	51.71
180	1.05	1.90	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.14
202.5	2.67	3.04	3.71	1.24	0.57	0.10	0.00	0.00	0.00	0.00	11.32
225	0.95	1.24	0.86	0.48	0.10	0.10	0.00	0.00	0.00	0.00	3.71
247.5	1.14	2.19	1.62	0.76	0.67	0.67	0.00	0.00	0.00	0.00	7.03
270	1.43	3.33	3.04	1.33	0.57	0.00	0.00	0.00	0.00	0.00	9.69
292.5	5.51	5.89	1.52	0.38	0.10	0.00	0.00	0.00	0.00	0.00	13.40
TOTAL	12.75	17.59	10.93	4.18	2.00	0.86	0.00	0.00	0.00	0.00	100.00

Table 3 Percentage occurrence of Wave height & direction at Ajanur for non-monsoon period (Feb-May)

Wave Height (m)	0.30	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	TOTAL
Direction										Calm %	41.23
157.5	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
180	3.34	2.55	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.06
202.5	1.76	2.84	2.55	1.37	0.00	0.10	0.00	0.00	0.00	0.00	8.62
225	1.08	1.08	0.39	0.59	0.69	0.49	0.00	0.00	0.00	0.00	4.31
247.5	0.69	0.98	1.08	1.18	0.49	0.00	0.00	0.00	0.00	0.00	4.41
270	2.15	4.11	3.33	0.78	0.29	0.00	0.00	0.00	0.00	0.00	10.68
292.5	9.21	9.99	0.49	0.88	0.00	0.00	0.00	0.00	0.00	0.00	20.57
315	2.74	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.04
TOTAL	21.06	21.84	9.01	4.80	1.47	0.59	0.00	0.00	0.00	0.00	100.00

Table 4 Percentage occurrence of Wave height & direction at Ajanur for entire period (Jan-Dec)

Wave Height (m)	0.3	0.5	1	1.5	2	2.5	3	3.5	4	4.5	TOTAL
Direction										Calm %	32.07
157.5	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
180	1.59	1.81	0.52	0.07	0.00	0.00	0.00	0.00	0.00	0.00	3.99
202.5	1.67	2.32	3.00	1.23	0.26	0.07	0.00	0.00	0.00	0.00	8.55
225	0.84	1.16	1.39	1.20	0.49	0.26	0.00	0.00	0.00	0.00	5.35
247.5	0.75	1.77	2.30	1.56	1.07	1.10	0.00	0.00	0.00	0.00	8.56
270	1.90	4.21	5.97	4.74	4.49	1.96	0.46	0.00	0.00	0.00	23.72
292.5	5.12	7.48	2.36	1.66	0.16	0.00	0.00	0.00	0.00	0.00	16.78
315	0.91	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
TOTAL	12.82	18.85	15.55	10.46	6.47	3.39	0.46	0.00	0.00	0.00	100.00

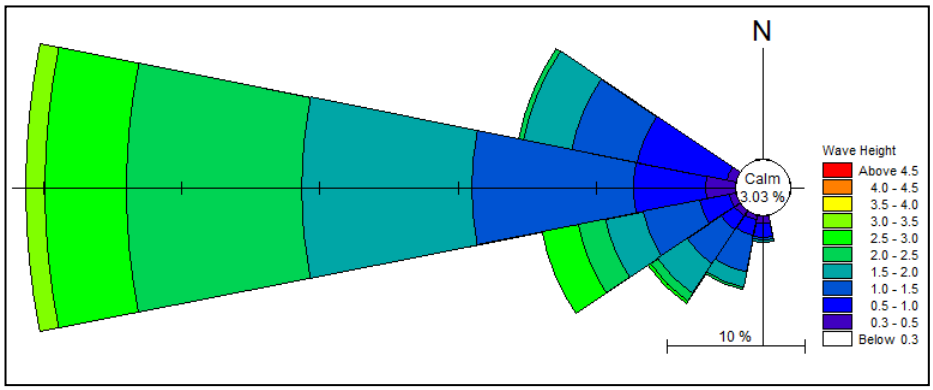


Figure 3 Wave rose diagram near Ajanur for South West monsoon (Jun-Sept)

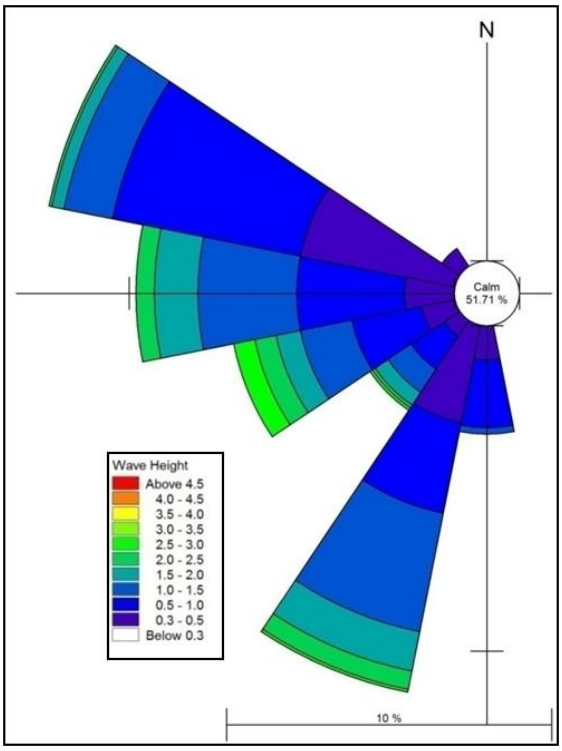


Figure 4 Wave rose diagram near Ajanur for North East monsoon (Oct-Jan)

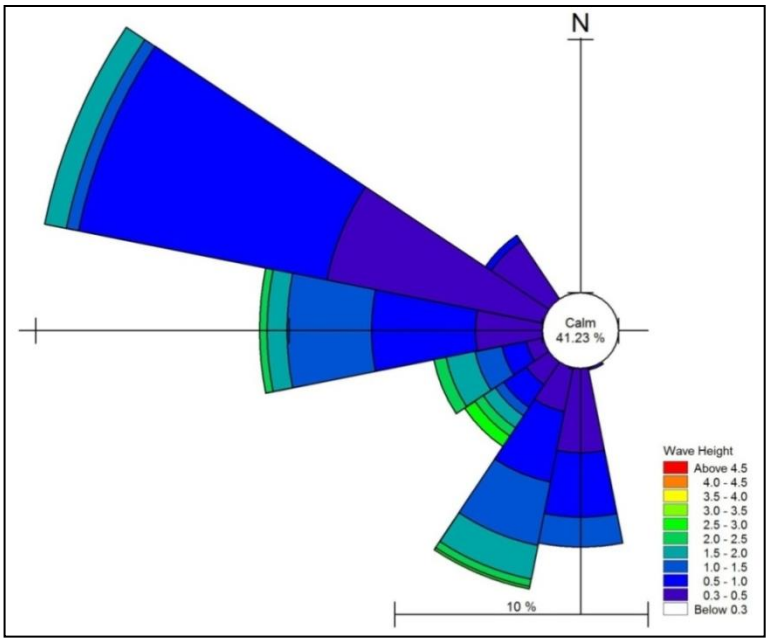


Figure 5 Wave rose diagram near Ajanur for non-monsoon (Feb-May)

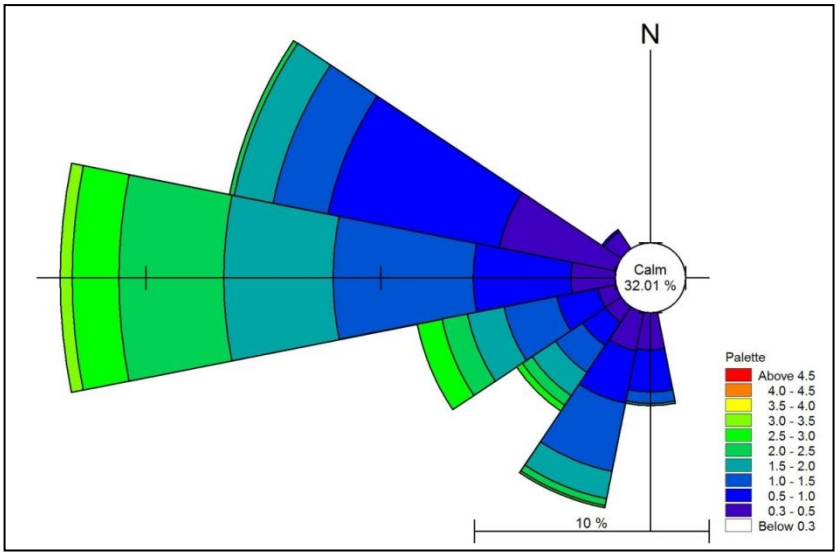


Figure 6 Wave rose diagram near Ajanur for entire year (Jan-Dec)

Figure 6 shows the percentage occurrence of wave distribution at 10m depth near Ajanur for the entire year. From the table 4, it can be interpreted that the predominant wave directions are SSW, SW, WSW, West and WNW with the percentage occurrence of 8.55, 5.35, 8.56, 23.72 and 16.78 respectively. The maximum wave height of 3.0m is observed from West direction. Table 1 shows the percentage occurrence of wave distribution at 10m depth near Ajanur for South-West Monsoon season. From table 1, it can be interpreted that the predominant wave directions are SW, WSW, West and WNW with the percentage occurrence of 8.02, 14.27, 50.83, and 16.42 respectively. The maximum wave height of 3.0m is observed from West direction. Table 2 shows the percentage occurrence of wave distribution at 10m depth near Ajanur for the North-East Monsoon season. From table 2, it can be interpreted that the predominant wave directions are SSW, SW, WSW, West and WNW with the percentage occurrence of 11.32, 3.71, 7.03, 9.7 and 13.4 respectively. The maximum wave height of 2.5m is observed from West-South-West direction. Table 3 shows the percentage occurrence of wave distribution at 10m depth near Ajanur for the Non-Monsoon season. From table 3, it can be interpreted that the predominant wave directions are SSW, SW, WSW, West and WNW with the percentage occurrence of 8.62, 4.31, 4.41, 10.68 and 20.57 respectively. The maximum wave height of 2.5m is observed from South-West direction.

Hence the wave conditions as input to the wave tranquility studies with MIKE 21 BW model have been shortlisted based on the percentage of occurrence are tabulated below in Table 5.

Table 5 Input wave conditions for wave tranquility studies

Incident Wave Direction	Incident Wave Height
SSW	1.5
SW	2.0
WSW	2.5
WEST	2.5
WNW	1.5

The permissible wave disturbance at berthing place depends on ship size, mooring & berthing system, method of loading & unloading used at berth and orientation of berth with respect to wave direction etc. The wave tranquility studies were carried out assuming wave tranquility limit as 0.3m which is considered as safe for berthing of fishing boats/vessels.

4. WAVE TRANQUILITY STUDIES

Mathematical model studies to assess wave tranquility in the harbour basin were carried out using MIKE 21 BW. The mean sea levels at Mangalore 1.0m, Kasargod1.0m, Kannur 1.02m have been obtained from Admiralty Charts. Therefore the mean tidal level of 1.0m at Kasargod has been considered for the wave tranquility studies using MIKE 21 BW. The model was simulated for all possible input wave conditions derived from wave transformation studies for the revised harbour layout proposed (by HED) and for three different scenarios of the revised layout by curtailing north breakwater length.

4.1 MIKE 21 BW

The Boussinesq Wave model, MIKE 21 BW, is the state-of-the-art numerical model for calculation and analysis of short and long-period waves in ports, harbours and coastal areas. MIKE 21 BW can also be used for detailed modeling of wave-induced current fields, surf zone dynamics and swash zone oscillations. The model is based on the numerical solution of the enhanced Boussinesq equations formulated by Madsen and Sørensen.

MIKE 21 BW is capable of reproducing combined effects of all important wave phenomena of interest in port, harbour and coastal engineering. These include:

1. Shoaling
2. Refraction

3. Diffraction
4. Wave breaking
5. Bottom friction
6. Moving shoreline
7. Partial reflection and transmission
8. Non-linear wave-wave interaction
9. Frequency spreading
10. Directional spreading

4.2 Wave Tranquility Studies for Revised Layout

As per the revised layout, northern breakwater is having a length of 1150m, southern breakwater is having length of 425m. The breakwater proposed for River training work is 435m long (Figure 2). Depth in harbor basin is considered as -4.0m.

4.3 Model Operation with Revised Layout

To simulate wave propagation with the revised layout, bathymetry was prepared as shown in Figure 7. The model region is considered as 4.0km X 4.0km and is discretised in a rectangular grid size of 3m.

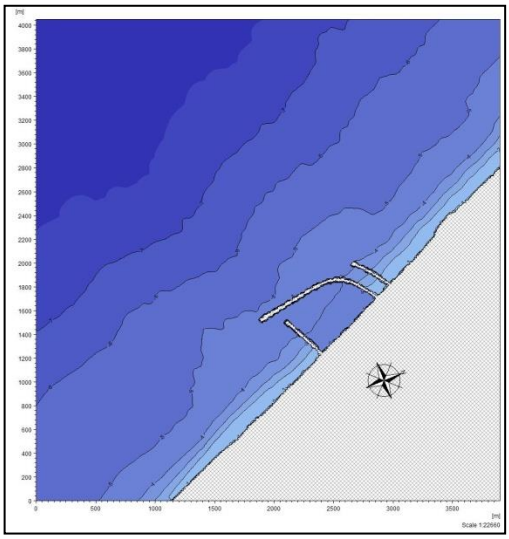


Figure 7 Bathymetry for wave propagation studies (revised layout)

The predominant wave directions at nearshore are SSW, SW, WSW, West and WNW with incident wave heights of 1.5m, 2.0m, 2.5m, 2.5m and 1.5m respectively (Table 5). The model is simulated for wave disturbance in the revised layout of harbour under five given wave conditions. The results are shown and discussed below.

Firstly, the model was simulated for incident wave height of 1.5m having direction SSW. The wave propagation and Wave height distribution in the model region and in the harbour are shown in Figure 8. From the figure, it could be seen that wave heights inside the harbor basin are less than 0.3m making harbour basin tranquil.

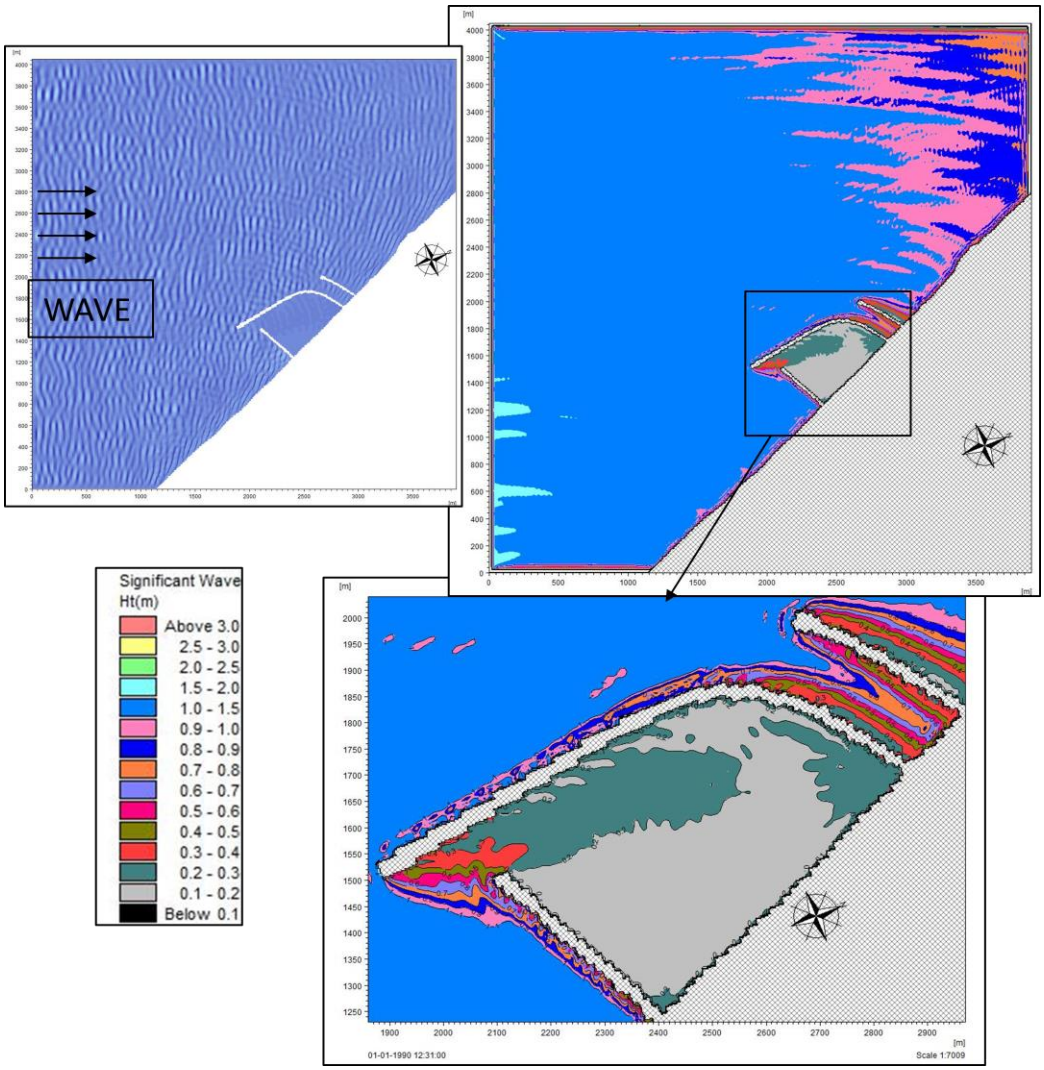


Figure 8 Wave propagation and wave height distribution in harbour for wave from SSW direction (incident wave height 1.5m)

Model was then simulated for incident wave height of 2.0m with direction SW. The wave propagation and Wave height distribution in the model region and in the harbor are shown in Figure 9 which shows that wave heights are less than 0.3m which represents tranquil condition for fishing vessels.

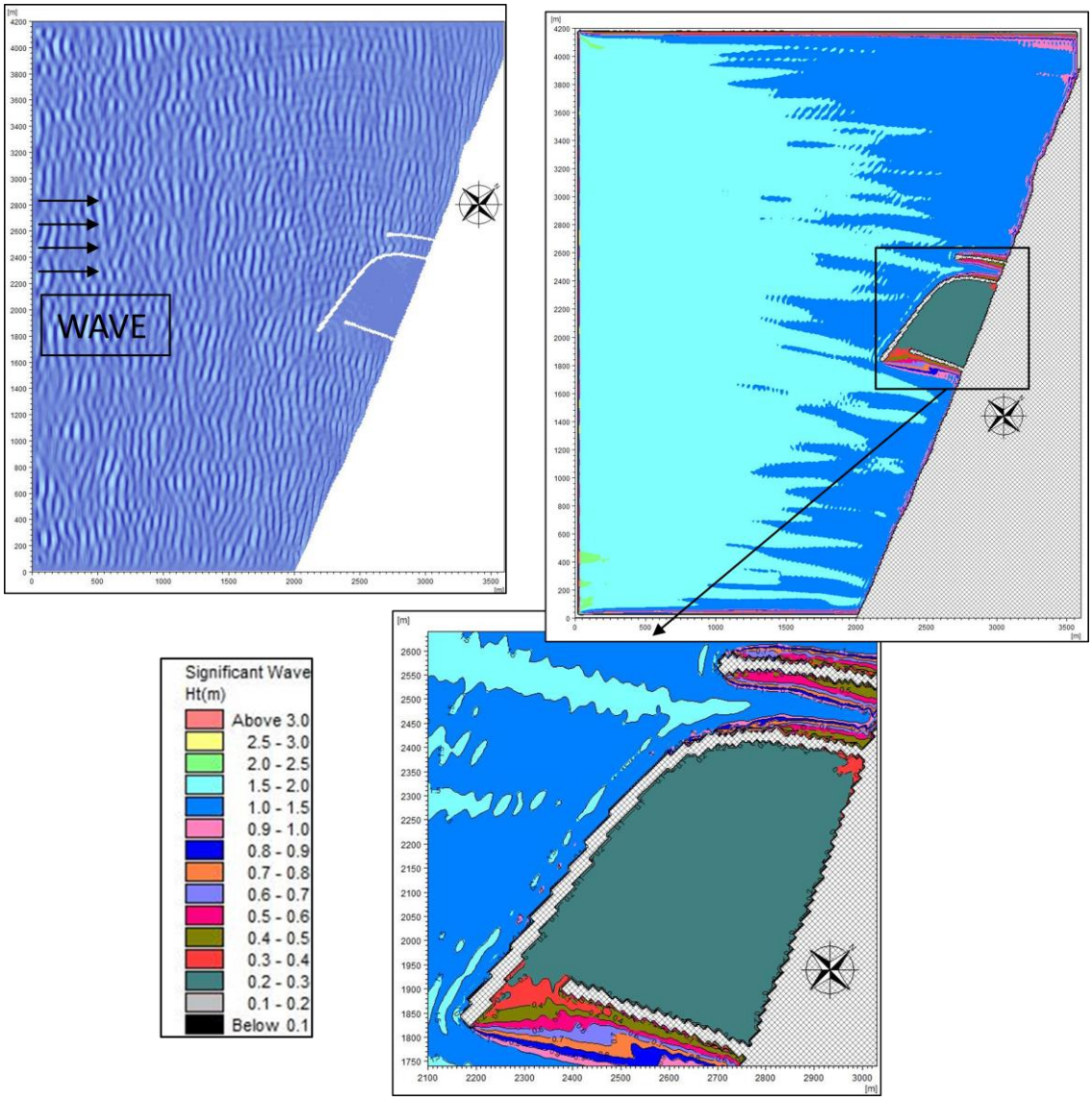


Figure 9: Wave propagation and wave height distribution in harbour for waves from SW direction (incident wave height 2m)

The wave propagation and wave height distribution in model region and in the harbor obtained from model simulation for incident wave height of 2.5m and direction WSW are shown in Figure 10. From the results, it could be seen that the entire harbour basin is tranquil as wave heights are less than 0.3m.

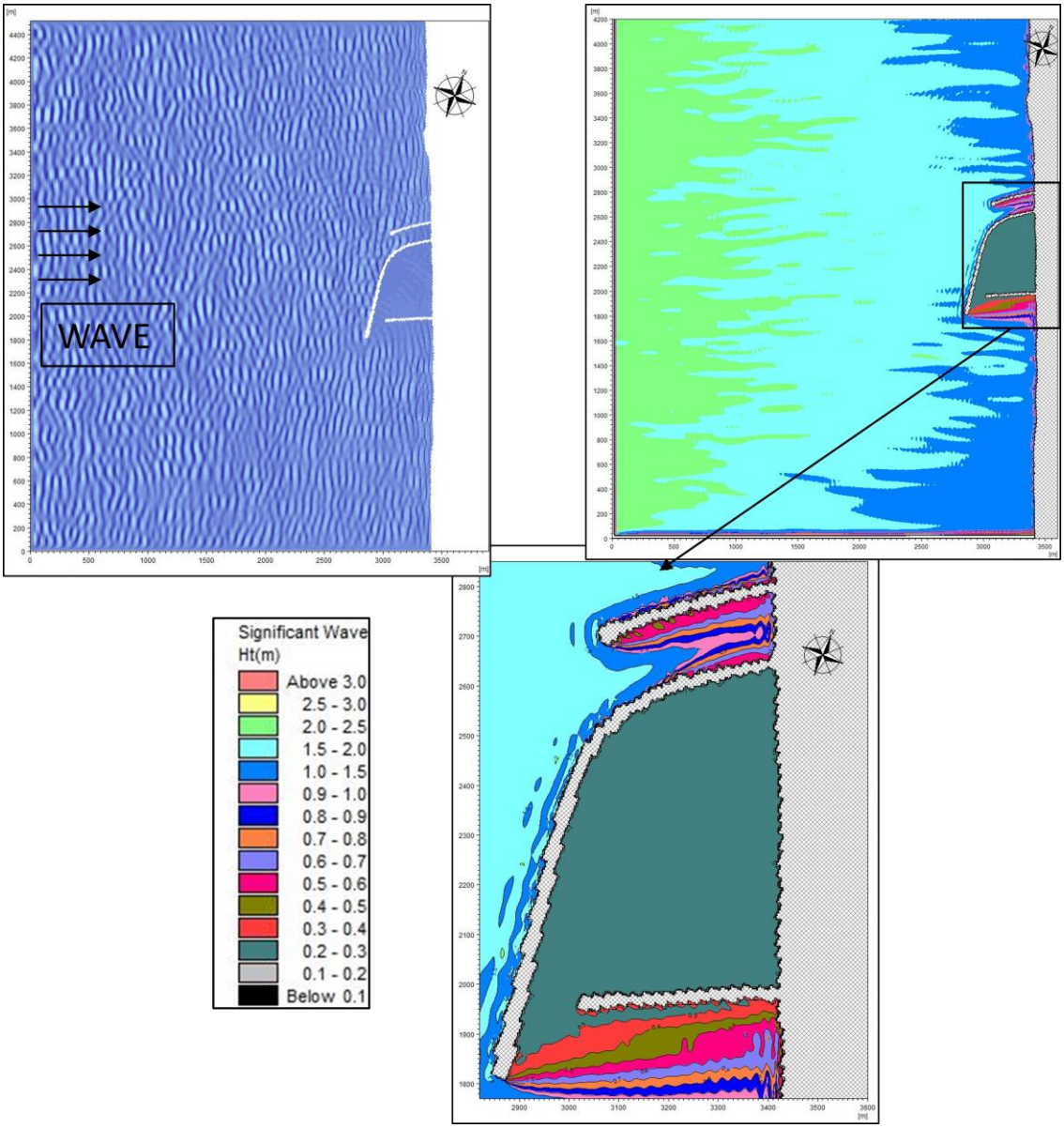


Figure 10 Wave propagation and wave height distribution in the harbour for waves incident from WSW direction (incident wave height 2.5m)

Similarly the model simulation for incident wave height of 2.5m and direction West indicated that complete harbour basin is tranquil with wave height less than 0.3m.The wave propagation and wave height distribution in the model region and in the harbour is shown in the Figure 11.

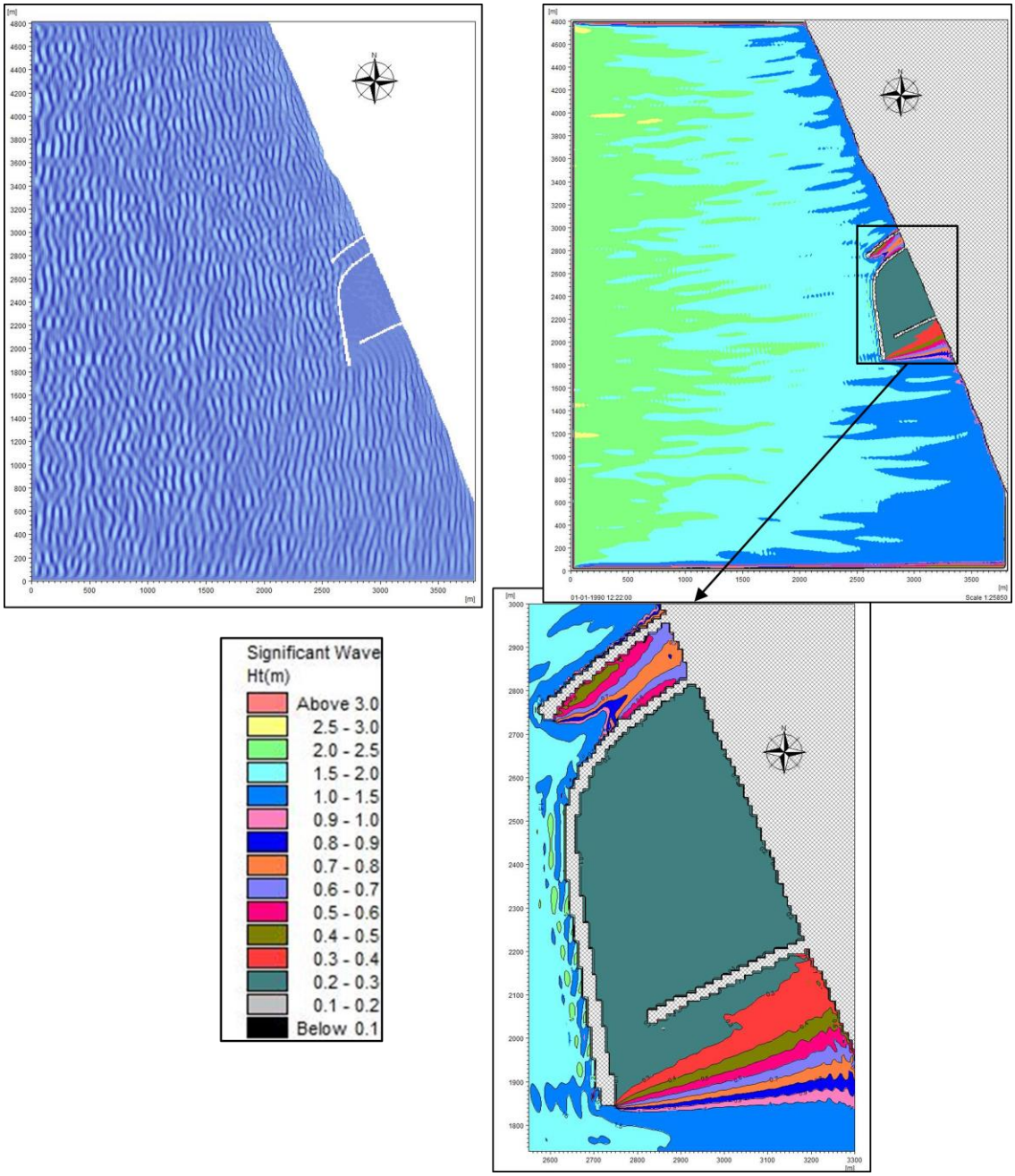


Figure 11 Wave propagation and wave height distribution in harbour for wave from West direction (incident wave height 2.5m)

Similarly the model simulation is carried out for incident wave height of 1.5m and direction WNW which indicated that entire harbour basin is tranquil as wave height less than 0.2m.The wave propagation and wave height distribution in the harbour is shown in Figure 12.

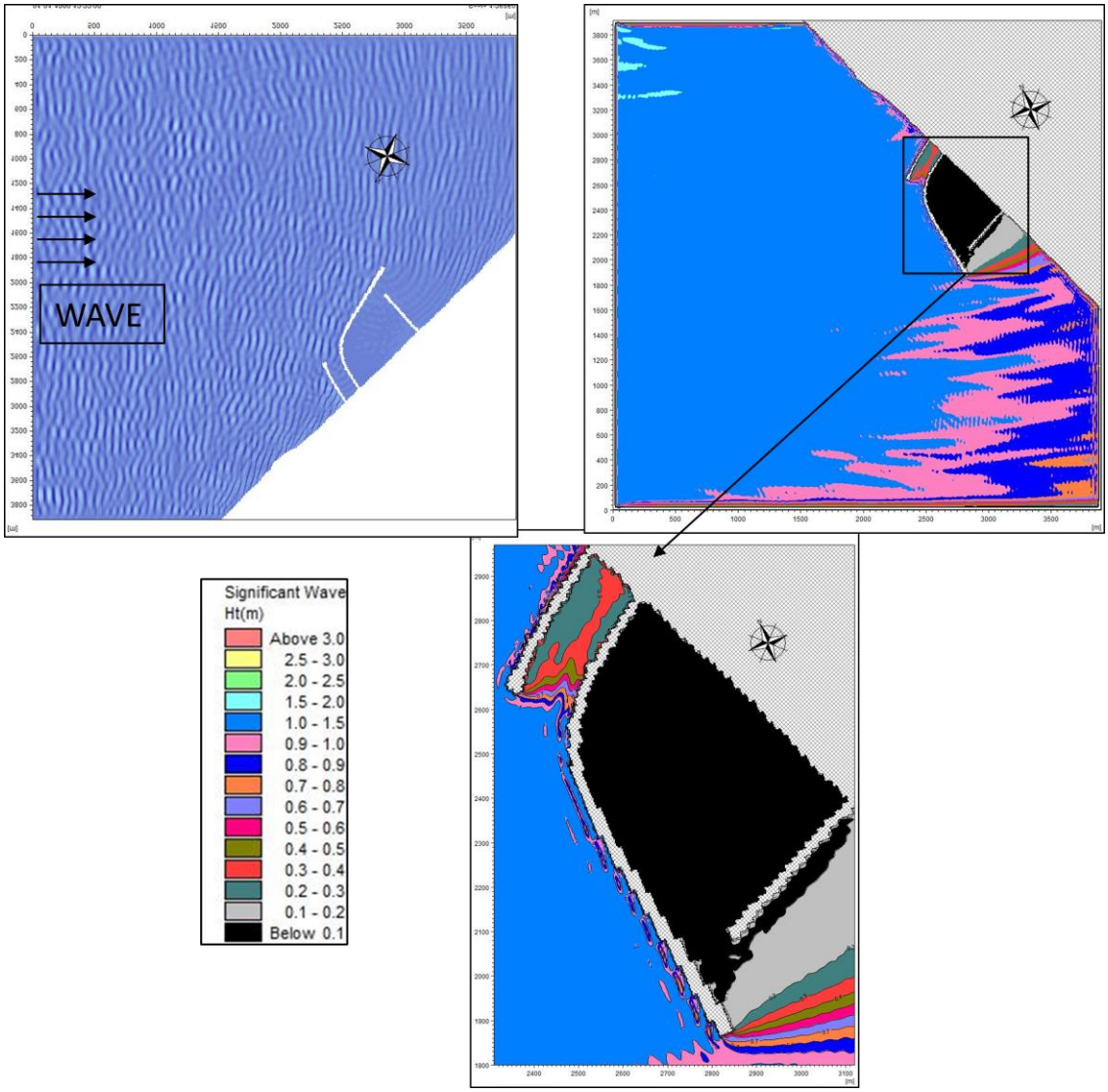


Figure 12 Wave propagation and wave height distribution in harbour for waves from WNW direction (incident wave height 1.5m)

Thus, considering wave tranquility limit 0.3m sufficient for fishing vessels likely to be operated in the region, the revised layout of the harbor (shown in Figure 2) would be suitable for operation throughout the year.

Further, in order to optimize the harbor layout, wave model was simulated for three different scenarios by curtailing length of the southern breakwater by 100m, 75m and 50m. The model was simulated for critical wave direction of SSW with incident wave height of 1.5m. The simulation results of three scenarios are discussed as under.

4.4 Model Operation with Scenario-1 *(by 100m Curtailment of Northern Breakwater)*

Bathymetry with the Scenario-1 i.e. revised layout having 100m curtailment of northern breakwater is shown in Figure 13.

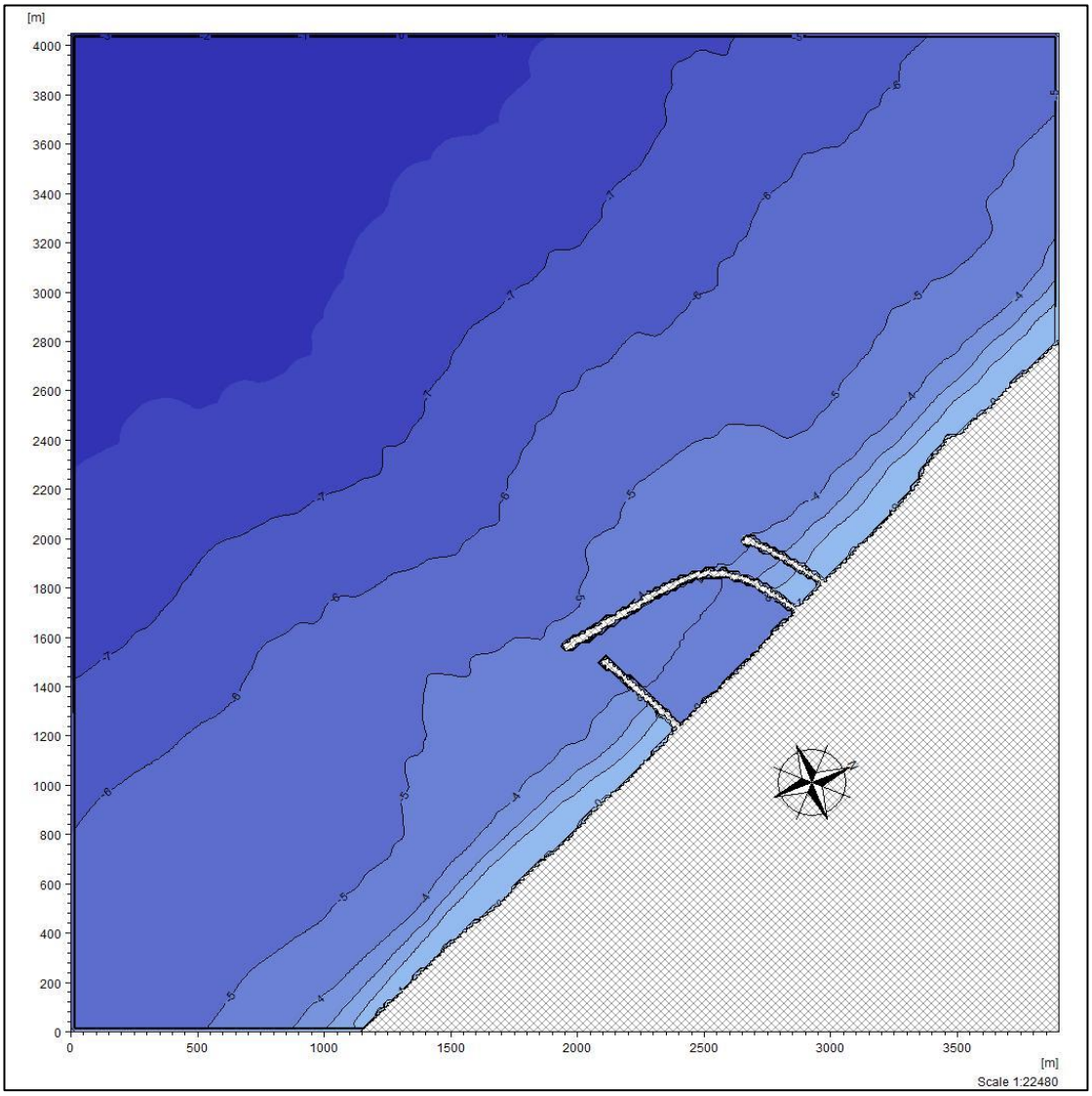


Figure 13 Bathymetry under Scenario-1 (revised layout with 100m curtailment of Northern breakwater)

The model is operated to simulate wave disturbance in harbour region under Scenario-1 (revised layout with 100m curtailment of northern breakwater) with SSW direction and wave height 1.5m. The wave propagation and wave height distribution in the model region and in the harbor are shown in Figure 14. From the figure, it is seen that wave heights of more than 0.3m could able to enter into the harbor basin making it rough (wave) to some extent.

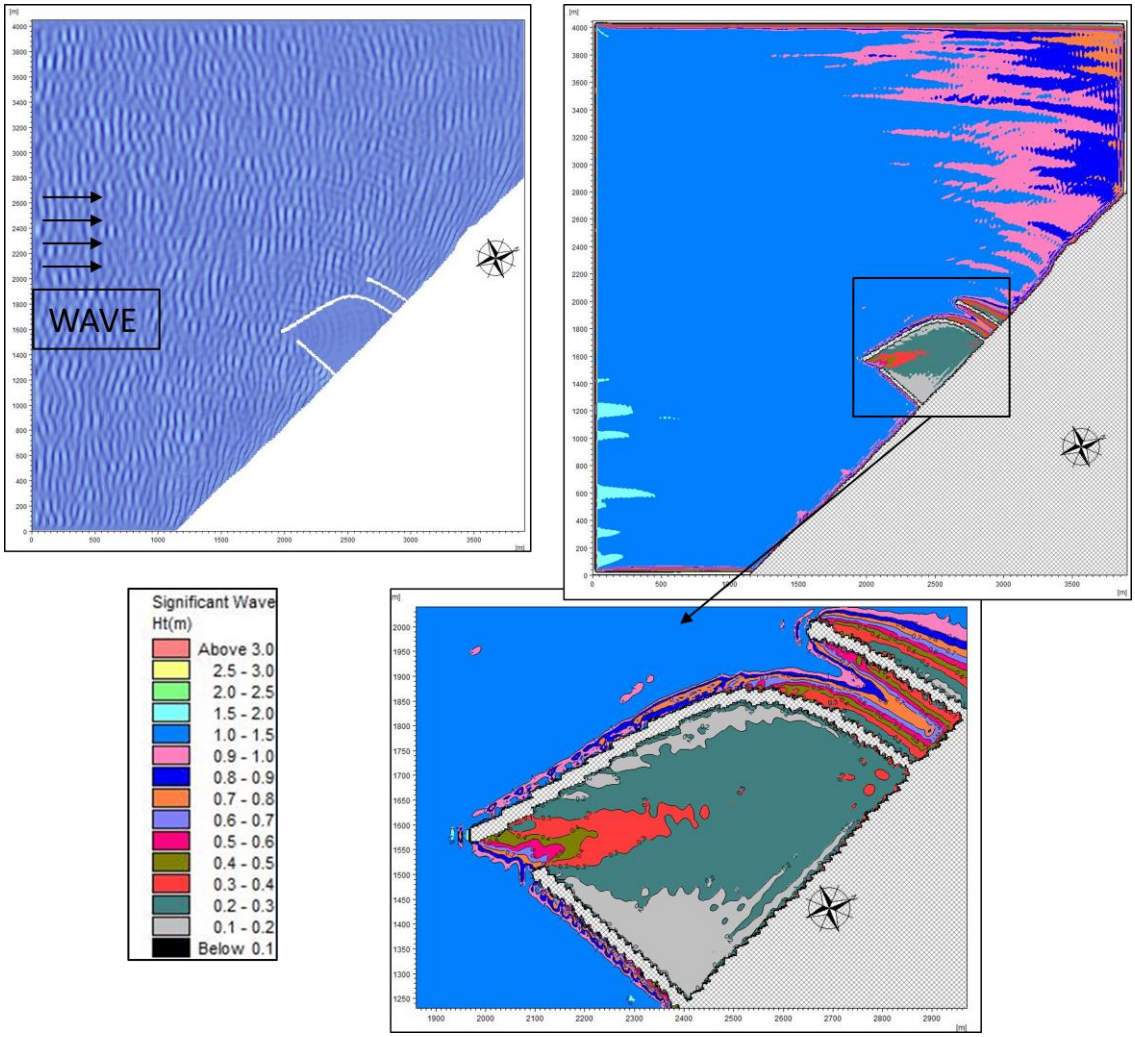


Figure 14: Wave propagation and height distribution for critical waves under Scenario-1

4.5 Model Operation with Scenario-2 *(by 75m Curtailment of Northern Breakwater)*

To simulate the wave propagation with Scenario-2 by 75m curtailment of northern breakwater, bathymetry is shown in Figure 15.

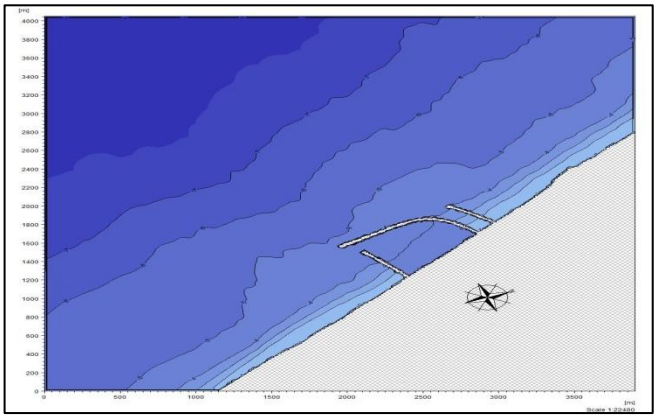


Figure 15 Bathymetry under Scenario-2 (revised layout with 75m curtailment of Northern breakwater)

The model is operated to simulate wave disturbance critical wave condition. The results are shown in Figure 16. From the figure, it could be seen that wave heights inside the basin are less than 0.3m. But near the harbor inlet, presence of wave heights ranging from 0.3m to 1.0m may create maneuverable problem to fishing vessels while entering into the harbour.

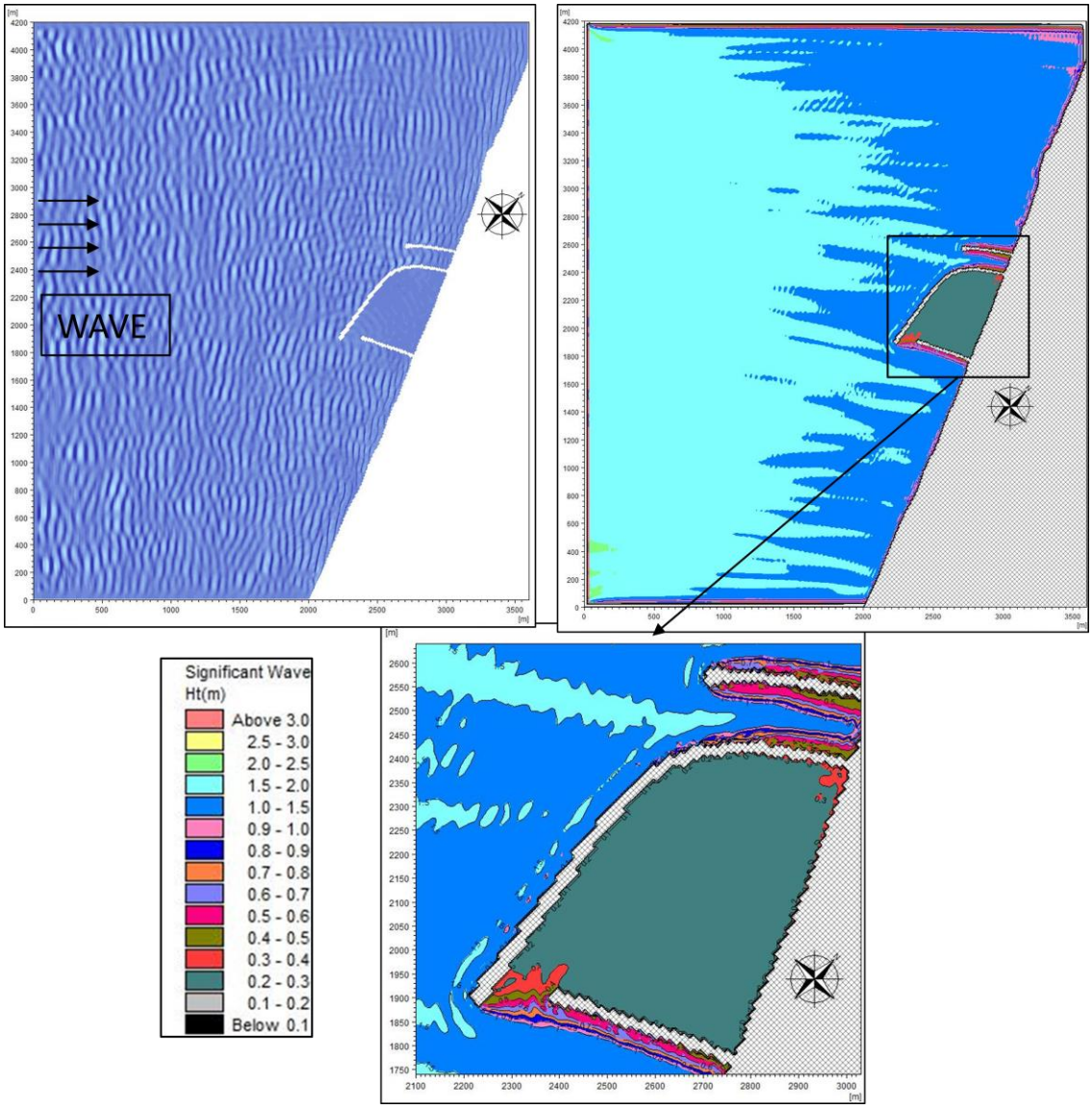


Figure 16 Wave propagation and height distribution in harbour under Scenario-2

4.6 Model Operation with Scenario-3 *(by 50m Curtailment of Northern Breakwater)*

To simulate wave propagation with Scenario-3 having 50m curtailment of northern breakwater bathymetry was modified as depicted in Figure 17.

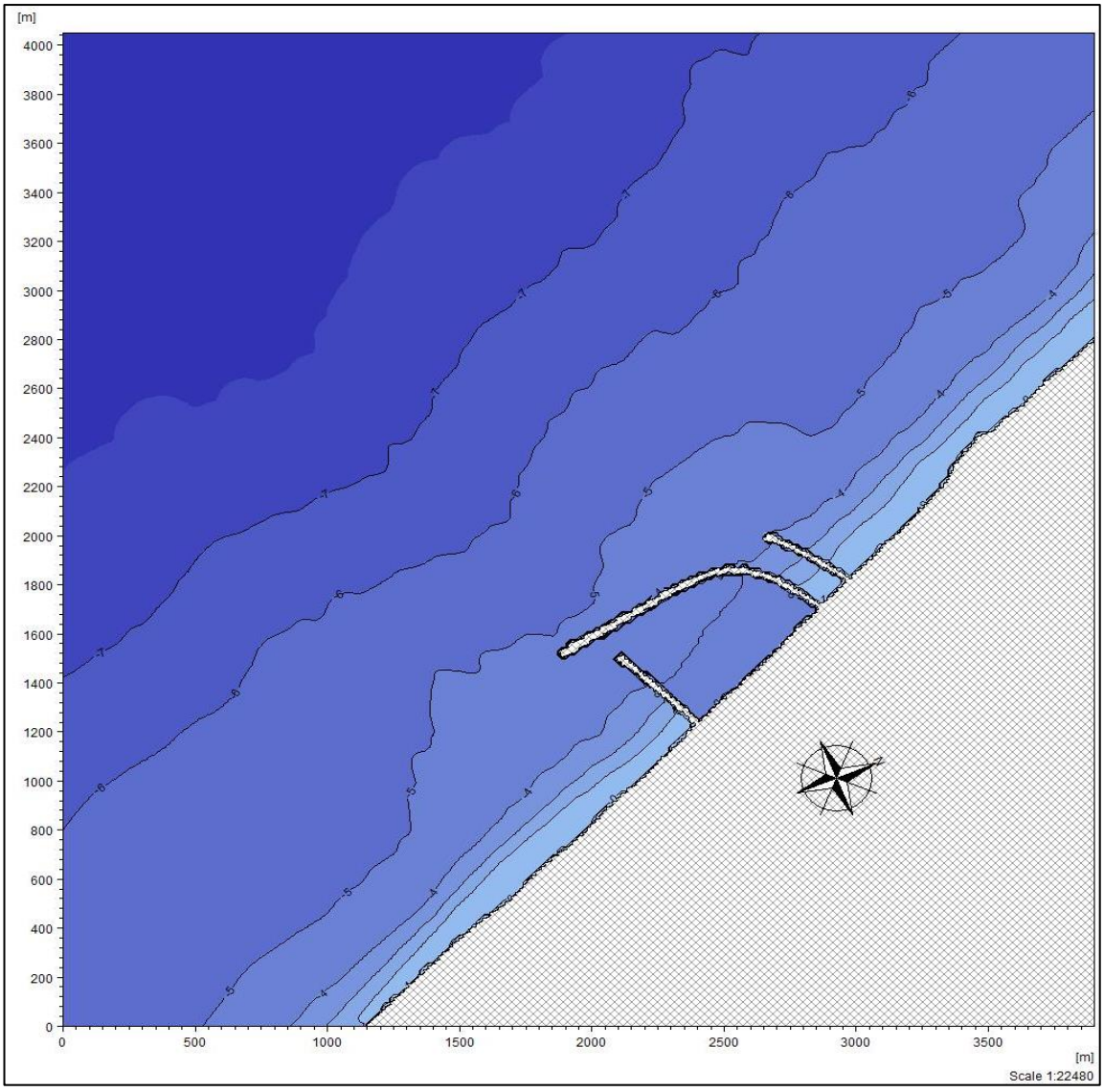


Figure 17 Bathymetry under Scenario-3 (revised layout with 50m curtailment of Northern breakwater)

The model is operated to simulate for critical wave condition and the results near the harbour are shown in Figure 18. From the figure, it could be seen that wave heights inside the basin are less than 0.3m. But in this case also at the entrance, wave heights ranging from 0.3m to 1.0m may create hindrance in maneuverability of fishing vessels while entering into harbor similar to earlier scenario (i.e. Scenario-2).

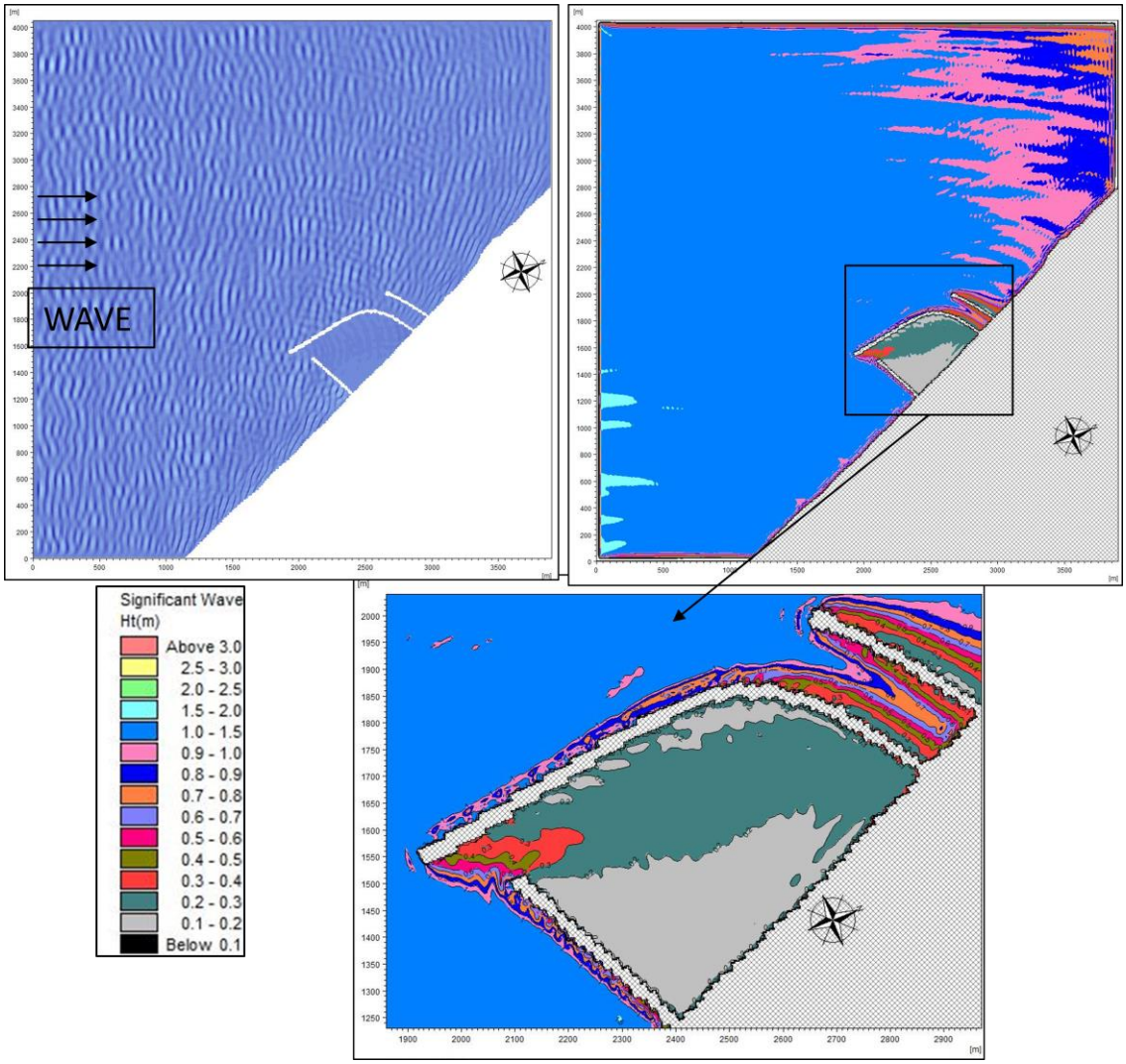


Figure 18 Wave propagation and height distribution in harbour under Scenario-3

5. CONCLUSIONS

I. Input wave conditions for wave tranquility studies are derived from MIKE21BW model. Wave models are simulated for the revised layout and for three different scenarios by curtailment of northern breakwater by 100m, 75m and 50m respectively. With respect to harbour entrance wave incident from SSW is found to be critical.

Incident Wave Direction	Incident Wave Height
SSW (critical direction)	1.5
SW	2.0
WSW	2.5
WEST	2.5
WNW	1.5

II. For the revised layout, wave heights in the harbor basin in all wave conditions are observed to be less than 0.3m which satisfies the criteria of tranquility limit. With this layout, the proposed harbour would be operational throughout the year.

III. With curtailment of north breakwater by 100m (Scenario-1) wave heights inside the basin are more than 0.3m. This layout is not suitable from wave tranquility point of view.

IV. With curtailment of North breakwater by 75m (Scenario-2) and 50m (Scenario-3), though wave heights inside the basin are less than 0.3m but at the entrance of the harbour wave heights are found to be in the range from 0.3m to 1.0m which may create difficulty in maneuvering to fishing vessels during entering into harbour.

V. The above statistics is based on ship observed visual wave data. These data are observed through ships. During stormy conditions ships try to avoid storm track, therefore these data do not contains storm data. Therefore operational days would be considered without storm. However, storms would be treated as non-operational days.

References

1. CWPRS Technical Report No. 5436 (November 2016) – Wave propagation studies to determine wave climate for the development of fish landing facilities at Ajanur, District kasargod ,Kerala
2. CWPRS Technical Report No. 5357 (February 2016) – Mathematical model studies for littoral drift and shoreline evolution due to the proposed fishery harbor at Ajanut, Dist. Kasargod, Kerala