Draft Report

Environmental Impact Assessment

Proposed Modernization and Expansion of Port Infrastructure for Fishing, Coastal, Multipurpose Cargo Berth and Liquid / General Cargo at Mormugao Port, Goa

Prepared for

MPT
मुरगांव पत्तन न्यास
An ISO 9001:2015 PORT

Mormugao Port Trust, Goa

Prepared by

ULTRA-TECH

Environmental Consultancy and Laboratory

NABET/EIA/1417/RA010

Lab Recognized by MoEF&CC – Govt. of India

November 2017

An ISO 9001-2008 Port
ISPS CODE Compliant

मुरगांव पत्तन न्यास
प्रशासनिक कार्यालय, हेडलैण्ड, सडा, गोवा–४०३ ८०४
MORMUGAO PORT TRUST
ADMINISTRATIVE OFFICE: HEADLAND, SADA, GOA-403 804
Mail:mptgoa@mptgoa.com,Website:www.mptgoa.com

Declaration by the Project Proponent

I, Smt. L. A. Mathew, Chief Engineer, Mormugao Port Trust, hereby, confirm that M/s. ULTRA – TECH (NABET Accredited EIA Consultants, NABET Certificate No. NABET/EIA/1417 /SA0011) have prepared the Environment Impact Assessment Report for Proposed Modernization and Expansion of Port Infrastructure for Fishing, Coastal, Multipurpose Cargo Berth and Liquid / General Cargo at Mormugao Port, Goa.

I hereby undertake the ownership of this EIA report on behalf of Mormugao Port Trust. I also confirm that the Mormugao Port Trust shall be fully accountable for any misleading information mentioned in this report.

Name: Smt. L. A. Mathew
Designation: Chief Engineer
Date: 08.11.2017

Declaration by Experts contributing to the EIA

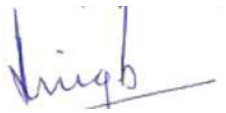
Project Name: Environment Impact Assessment Report for Proposed Modernization and Expansion of Port Infrastructure for Fishing, Coastal, Multipurpose Cargo Berth and Liquid / General Cargo at Mormugao Port, Goa

Client Name: Mormugao Port Trust

Period of EIA: from March 2017 to November 2017

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

EIA coordinator: Dr. Mahesh D. Zingde



Date: 06.11.2017

Period of involvement: March 2017 to November 2017

Associate EIA Coordinator: Mr. Vikrant A. Kulkarni

Date: 06.11.2017

Period of involvement: March 2017 to November 2017

Contact information:

Ultra Tech Environment Consultancy and Laboratory
NABET Accredited EIA Consulting Organization
Unit No, 224, 225, 206 Jai Commercial Complex,
Eastern Express Highway, Opp. Cadbury Factory,
Khopat, Thane (w).400601

Functional area experts:

Sr. No.	Functional Area	Name of Expert	Period of Involvement	Signature
1	AP	Mr. Shekhar Tamhane	March 2017 to November 2017	
2	WP	Mrs. Deepa Tamhane Karnik	March 2017 to November 2017	
3	MSW	Mr. Santosh Gupta	March 2017 to November 2017	
4	SHW	Mr. Santosh Gupta	March 2017 to November 2017	
5	SE	Dr. Kishore Wankhede	March 2017 to May 2017	
6	EB	Dr. T. K. Ghosh	March 2017 to November 2017	
7	LU	Mr. Yogesh Raskar	August 2017 to September 2017	
8	RH	Mr. S. L. Bonde	March 2017 to November 2017	

Project Team Members:

1. Mrs. Ananthitha Anandan
2. Ms. Thara K Thankappan
3. Ms. Haritha V Mohanan
4. Mr Rahul Raj V R

Declaration by the Head of the accredited consultant organization/ authorized person

I, **Shekhar M. Tamhane**, hereby, confirm that the above mentioned experts prepared the Environment Impact Assessment Report for Proposed Modernization and Expansion of Port Infrastructure for Fishing, Coastal, Multipurpose Cargo Berth and Liquid / General Cargo at Mormugao Port, Goa. I also confirm that the consultant organization shall be fully accountable for any mis-leading information mentioned in this statement.

Name: Shekhar M. Tamhane

Designation: Managing Director

Name of the EIA consultant organization: ULTRA – TECH

NABET Certificate No. & Issue Date: NABET/EIA/1417/SA0011

TOR Compliance

Standard ToR Published by MoEF&CC for Port Projects in April 2015		
Sl.No	**ToR Point**	**Compliance**
1.	Reasons for selecting the site with details of alternate sites examined / rejected / selected on merit with comparative statement.	The proposed project development is within existing Mormugao Port area. Hence, alternative sites are not considered.
2.	Details of the land use break-up for the proposed project.	The project does not involve any change in the land use as all constructions are proposed on the reclaimed marine area with in the Port Basin under Mormugao Port Trust Jurisdiction. Details of the Project are presented in Chapter 2
3.	Submit the present land use and permissions required such as forest, agriculture, land acquisition etc.	All construction activities proposed are under the jurisdiction of MPT. Hence, there is no land acquisition.
4. `	Examine and submit the water bodies	The project site is located at the mouth of Zuari River System and Arabian Sea. Further details presented in Chapter 3.6
5.	Submit wildlife clearance from standing committee of NBWL	There is no sanctuary or national park within 10 km from project boundary. Hence, Wildlife Clearance is not applicable.
6.	Submit a copy of the contour plan with slopes, drainage pattern of the site and surrounding area	The project is within port limit and largely on marine zone. Contour and drainage pattern are presented in Chapter 3.5.
7.	Submit the details of terrain, level with respect to MSL, source of filling material and transportation details.	Details of MSL are presented in Chapter 3.7. Source of reclamation material is presented in Chapter 2.3. Construction materials will be transported through existing roads.
8.	Examine road/rail connectivity to the	Site has good road and rail connectivity. Details

	project site. Detailed traffic study should be made considering present passenger and cargo traffic.	presented in chapter 3.13.7. Proposed project involves mainly liquid and break bulk cargo. Liquid will be transported through pipelines and break bulk will be transported through rail network.
9.	Submit details regarding R&R involved in the project	Project is located within Port limit. No R&R involved
10.	Submit a copy of layout superimposed on the HTL/LTL map demarcated by an authorized agency on 1:4000 scale, with recommendations of SCZMA	HTL/LTL map in 1:4000 scale superimposing the project layouts have been prepared and is attached as Appendix II.
11.	Submit the status of shore line change at the project site	National Center for Sustainable Coastal Management has carried out shoreline changes of Goa. Mormugao region is stable coast. Detailed map is attached as Appendix VII.
12.	Details of the layout plan including details of channel, breakwaters, dredging, disposal and reclamation	Layout of project presented in Chapter 2.3
13.	Details of handling of each cargo, storage, spillage control measures	The details cargo handling, storage are given in Chapter 2.1
14.	Submit the details of fishing activity and likely impacts on the fishing activity due to the project. Specific study on impacts of construction and piling on marine life.	Details are presented in Chapter 2.3. Proposed project involves development for local fishermen development.
15.	Details of oil spill contingency plan	MPT has Oil Spill Contingency Response Plan. Detailed Plan attached as Appendix V
16.	Details of bathymetry study	Presented in Chapter 3.7.4
17.	Details of ship tranquility study	CWPRS, Pune has carried out hydrodynamic modeling studies. Detailed reports are attached as Appendix III.

18.	Examine the details of water requirement, impact on competitive user, treatment details, and use of treated waste water. Prepare a water balance chart.	Details of the water requirement during construction and operation phase are presented in Chapter 2.4.2.
19.	Details of rainwater harvesting and utilization of rain water.	Not Applicable
20.	Examine details of Solid waste generation treatment and its disposal.	Presented in Chapter 4.8.
21.	Details of desalination plant and the study for outfall and intake.	Not Applicable
22.	Examine baseline environmental quality along with projected incremental load due to the proposed project/activities. One season data may be used for EIA/EMP report	Presented in Chapter 3. Baseline data collected during March'17 to May'17.
23.	The air quality monitoring should be carried out according to the notification issued on 16th November, 2009.	The Ambient Air Quality Monitoring carried out during period of March'17 till May'17 is given in Chapter 3.9
24.	Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.	A detailed Environmental Management Plan is presented in Chapter 8. Proposed Monitoring Plan during Construction and Operation Phase is given in Chapter 5
25.	Submit details of a comprehensive Risk Assessment and Disaster Management Plan including emergency evacuation during natural and man-made disasters	Quantitative Risk Assessment and Disaster Management Plan are given in Chapter 6.6 and Chapter 6.5 respectively. Detailed QRA report is attached as Appendix VI and Detailed DMP is attached as Appendix V
26.	Submit details of the trees to be cut	No clearance of existing vegetation required as

		proposed development is mostly on reclaimed land.
27.	Examine the details of afforestation measures indicating land and financial outlay.	Greenbelt plan of MPT is attached as Annexure VIII.
28.	A detailed draft EIA/EMP report should be prepared	EIA report prepared in accordance with ToR issued by MoEF&CC vide F.No. 10-8/2017-IA-III; IA/GA/MIS/62248/2017 dated 13.04.2017
29.	Details of litigation pending against the project	There is no litigation pending against the project.
30.	The cost of the Project	Total Project Cost will be 645.65
Specific ToR issued by EAC vide Letter No. F. No. 10-8/2017-IA-III dated 8th May 2017		
1	Importance and benefits of the project	Presented in Chapter 7
2	A separate chapter on status of compliance of Environmental Conditions granted by State/Centre to be provided. As per circular dated 30th May, 2012 issued by MoEF&CC, a certified report by RO, MoEF&CC on status of compliance of conditions on existing port to be provided in EIA-EMP report.	Compliance report prepared by RO-MoEF&CC Bangalore is attached as Appendix I.
3	Recommendation of the SCZMA.	Proposal will be submitted to SCZMA after public hearing.
4	A detailed analysis of the physico-chemical and biotic components in the highly turbid waters round the project site (as exhibited in the Google map shown during the presentation), compare it with the physico- chemical and biotic components in the adjacent clearer (blue)	Physic-chemical parameters of both marine and surface water are monitored. Details of the monitoring reports are represented in Chapter 3.7.

	waters both in terms of baseline and impact assessment and draw up a management plan.	
5	Study the impact of dredging on the shore line.	Impacts due to dredging are presented in Chapter 4.4 and 4.5
6	A detailed impact analysis of rock dredging.	Sea bottom at proposed project location is mainly sandy. Rock dredging is not envisaged.
7	Action plan for disposal of dredged soil and rocks.	Dredged material will be disposed off in the existing marine spoil grounds identified and demarcated by CWPRS, Pune.
8	Dispersion modelling for the dumping of the dredge materials shall be carried out. The study report shall be incorporated	CWPRS, Pune has carried out hydrodynamic modeling studies. Detailed reports are attached as Appendix III.
9	Details of air pollution control measures to be taken as well as cost to be incurred	Mitigation measures adopted to reduce pollution, presented in Chapter 4.6 and Chapter 8.1
10	The Marine biodiversity impact assessment report and management plan through the National Institute of Oceanography (NIOS) or any other institute of repute on marine, brackish water and fresh water ecology and biodiversity. The report shall study the impact of the project activities on the intertidal biotopes, corals and coral communities, molluscs, sea grasses, sea weeds, sub tidal habitats, fishes, other marine and aquatic micro, macro and mega flora and fauna including benthos, plankton, turtles, birds etc. as also the	Marine biodiversity impact assessment report and management plan is prepared by National Institute of Oceanography

	productivity. The data collection and impact assessment shall be as per standards survey methods.	
11	Layout plan of existing and proposed Greenbelt	Attached as Annexure VIII.
12	A tabular chart with index for point wise compliance of above TORs.	Noted and complied
13	Public hearing to be conducted and issues raised and commitments made by the project proponent on the same should be included in EIA/EMP Report in the form of tabular chart with financial budget for complying with the commitments made.	Noted. Proposal is submitted for Public Hearing

Table of Contents

List of Tables

List of Figures

List of Annexures

Annexure I – Proposed Layout Superimposed on Google Image

Annexure II – Laboratory Reports of Soil Analysis

Annexure III - Laboratory Reports of Surface and Groundwater Analysis

Annexure IV - Laboratory Reports of Marine Water Analysis

Annexure V - Laboratory Reports of Marine Sediment Analysis

Annexure VI - Laboratory Reports of Ambient Air Quality Monitoring

Annexure VII - Laboratory Reports of Noise Monitoring

Annexure VIII – Greenbelt Layout

List of Appendix

Appendix I – RO, MoEF&CC Certified Compliance Report

Appendix II – HTL/LTL Map Prepared by IRS, Anna University Chennai

Appendix III – Hydrodynamic Modeling Reports Prepared by CWPRS, Pune

Appendix IV – Oil Spill Contingency Plan of Mormugao Port Trust

Appendix V – HAZOP Study for Liquid Cargo Berth

Appendix VI – Quantitative Risk Assessment for Liquid Cargo Berth

Appendix VII – Shoreline Changes Map Prepared by NCSCM, Chennai

1. INTRODUCTION

1.1. Mormugao Port

Mormugao Port, commissioned in 1885 is one of the oldest ports on the west coast of India in the state of Goa and is blessed with a protected open type natural harbour. Over the years, it has developed a deep draft channel. With its location at the mouth of the Zuari River, it is a crucial component in the flourishing export industry of the state of Goa. It became one amongst the major ports of the country in 1964 and has been relentlessly serving the nation in its economic development. The location of this Port is depicted in Figure 1.1.

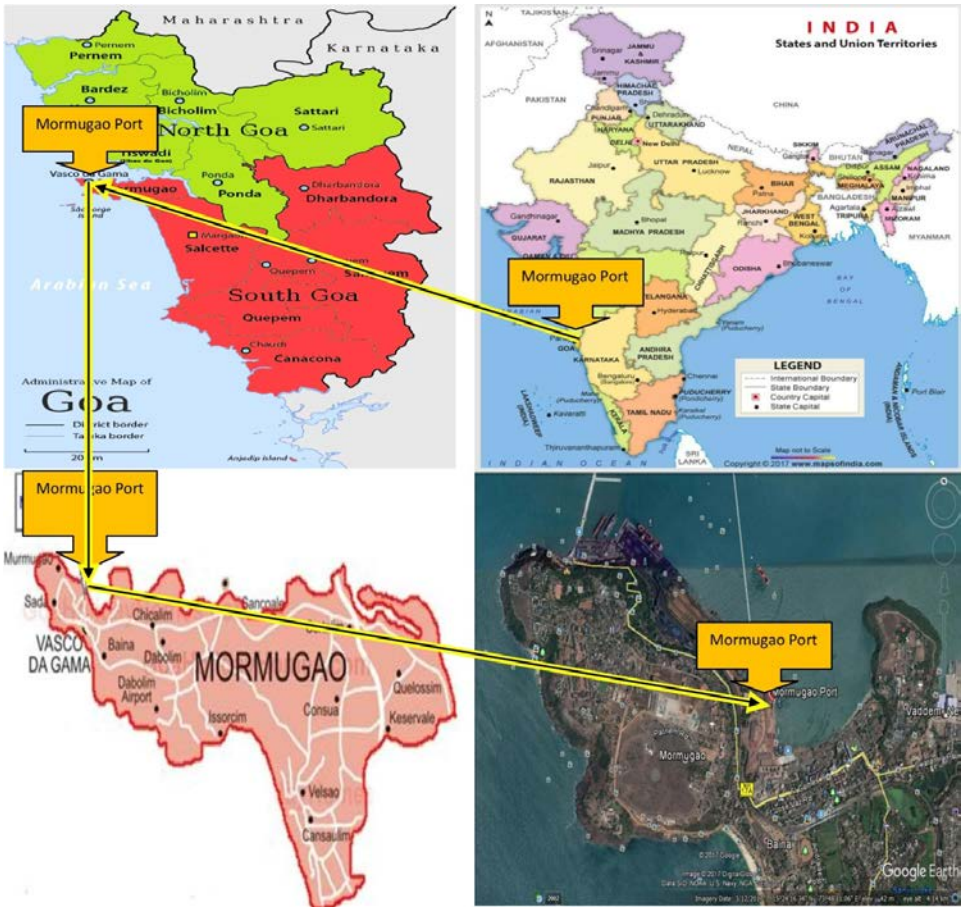


Figure 1.1: Location of Mormugao Port

Proximity of the port with various mining regions in Goa has rendered it mainly an iron ore port handling largest quantum of ore exports amongst all the Indian Ports. After the Supreme Court

banned iron ore mining in the Goa in 2012, iron ore exports have come down. At present, the iron exported through this port constitutes 39 per cent of the total iron ore exports from India. The port is set to diversify into other commodities as well as containers and has been witnessing a steady increase in liquid bulk and general cargo traffic. The requirements of coal from various steel industries and power generating units have made it an attractive and cost effective destination for coal imports and steel exports. Port records show that the volume of coal arriving at the port rose from 7 million tonnes in 2012-'13 to nearly 12 million tonnes in 2015-'16 – two-thirds of the total cargo handled that year.

During the year 2015 -16 the Port witnessed a growth of 41% over the previous year. For the current year (2016-17) too, the growth recorded, so far is over 62% over the previous year. To keep up with the fast pace of growth the port modernization and expansion is inevitable.

1.2. Existing Port Facilities

At the time of its commissioning in 1885, the Mormugao Port comprised of 3 berths along with a breakwater. The infrastructure gradually kept growing and by 1922, berths 4 and 5 were built and the breakwater was extended to its present length of 522.40 m. A mole of 270 m was added. In 1959 the Mechanical Ore Handling Plant was set up at Berth No.6. Berth 7 was constructed as an adjunct to it. A dedicated mineral oil berth, berth No. 8 was constructed in 1976. The mechanical ore handling plant was established in berth No. 9. Two multi-purpose general cargo berths berth No.10 and No. 11 were constructed and commissioned in 1985 and 1994 respectively. The Mechanical Ore Handling Plant installed at Berth No. 6 was de-commissioned in 1992 due to obsolesce. The age old berths 1 to 3 were leased out for installing a modern ship repair facility, which was commissioned in 1995.

Accordingly, Mormugao Port managed by the Mormugao Port Trust (MPT), currently has total 11 berths out of which 6 berths (Berth No. 1,2,3,5,6,7) are leased out to some other organizations and remaining 5 berths (Berth No. 4,8,9,10,11) are under the operation of Mormugao Port Trust. Significant cargoes handled at the Port include coal, ammonia and phosphoric acid fertilizer components, steel coil and slab, limestone, petroleum oil lubricants, molasses, and a small volume of containers. Non-cargo vessels include cruise ships, oilfield supply vessels, vessels of

Navy, Coast Guard, NIO, Fisheries Survey of India etc. In addition, supplies for the Indian Antarctic expeditions are marshaled at Mormugao.

The existing facilities at Mormugao Port includes

- x Berths and Mooring Dolphins
- x Cargo Handling and Storage Facilities
- x Mechanical Ore Handling Plant
- x Streamloading, Discharging facilities, Port railway facilities and bunkering provisions
- x Cruise Tourism

The details of the existing berthing facilities at the Mormugao Port are shown in Figure 1.2.

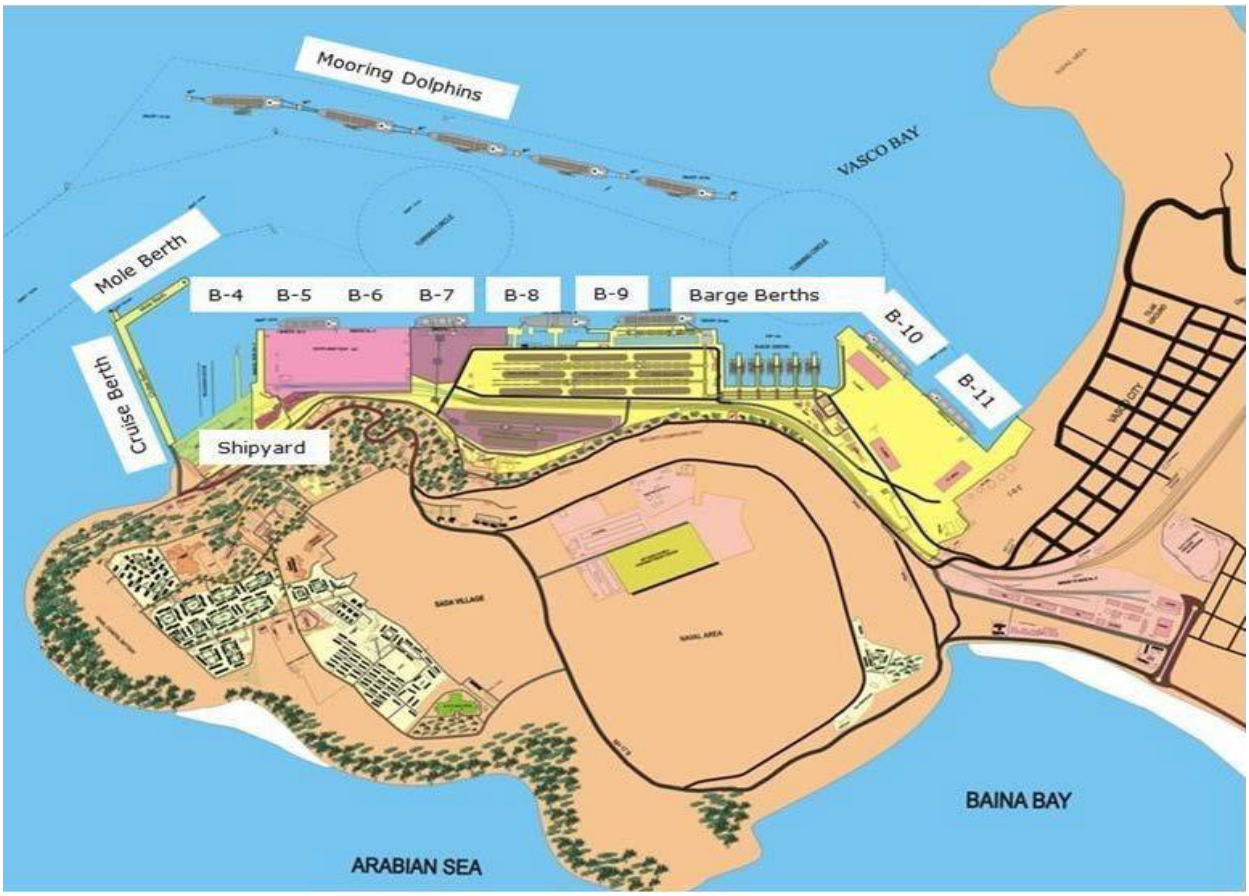


Figure 1.2: Location of Mormugao Port and existing Berthing Facilities

1.3. The Proposed Modernization and Expansion

Mormugao Port has a total operational area of 250 acres which is inadequate to cater to ever increasing trade demands. Temporary fish landing platform occupies prominent waterfront area close to Berth No.11 making development of Port infrastructure difficult. Mormugao Port Trust therefore proposes following Modernization and Expansion of Port Infrastructure:

a. Construction of Fishing Jetty.
b. Development of Berth for Liquid bulk (Petroleum products including LPG) and other General Cargo.
c. Development of Multipurpose Cargo Berth.
d. Construction of Passenger Jetty, Launch Jetty, and Port Craft Jetty.
e. Deepening of Berths 10 & 11 pockets from -13.10 to -15.0 m.
f. Deepening of Breakwater Berth from -9.5 to -11.5m

1.4. Overview of the Environmental Setting around Mormugao Port

The coordinates of Mormugao port are 15° 25' N and 73° 47' E. It is an excellent natural harbour and over the years, the port has deepened the channel and the harbour areas (-14.4m below Chart Datum). Further, deepening of the channel to -19.80 m for Capesize vessels is in process. The existing total cargo handling capacity is 44.35 MTPA. Mormugao Port is well connected through road and rail network with all major towns of not only Maharashtra and Karnataka, but the rest of India as well.

The Environmental Setting around Mormugao Port is depicted in Table 1.1.

Table 1.1: Environmental Setting around Mormugao Port

S.No.	Particular	Details
1	Project Location	Vasco Bay, Mormugao, South Goa
2	Toposheet No. of OSM	OSM map 48E/15
3	Site Coordinates	Latitude 15^0 25' North Longitude 73^0 47' East

S.No.	Particular	Details
4	Climatic Conditions	Based on IMD – Goa (Annual) – 30 years data qAnnual Mean Max Temp: 36.5 0C (Summer) qAnnual Mean Min Temp: 16.3 ^{0}C (Winter) qAnnual Total Rainfall: 2978 mm qPredominant Wind Direction : W, SW
5	Railway Station	Vasco da Gama Railway station at 0.86 km in South direction
6	Airport	Dabolim Airport – 3 km in South West direction
7	Sea Port	Project site falls within Mormugao Port Trust limit
8	Village/Major Town	Vasco City
9	Ecologically Sensitive Areas	Dr. Salim Ali Bird Sanctuary is located about 13 km North. Corals in Grande island located about 7 km South West. Mangrove vegetation is located as few patches in Zuari Estuary at about 7 km East.
10	Historical/ Tourist Place	qMurmugao Fort – 1.9 km to the West qBaina beach - 2.4 km to the South qGrand Mother's Hole Beach – 2.4 km to the West qDona Paula View Point – 5.3 km to the North qBogmalo beach -6.1 km to the South West qBritish Cemetery – 6.25 km to the North qSt. Jacinto Island - 6.7 km to the East qOur Lady of Rosary Church – 8.6 km to the North East qVelsao Beach – 9.8 km to the South East qAguada Lighthouse – 9.8 km to the North qAguada Fort – 10 km to the North
11	Beach resorts	qHotel La-Paz Gardens at 0.7 km to the Southeast qCoconut Creek Resort at 4.2 km in the Southeast qBogmallo beach resort at 4.7 km in the Southeast

<table>
<tr><th>S.No.</th><th>Particular</th><th>Details</th></tr>
<tr><td></td><td></td><td>qPonto Do Soi resorts at 5.7 km to the North
qCidade de Goa at 5.9 km to the North
qSwimsea beach Resort at 6.7 km to the North
qMarriot Resort & Spa at 9.3 km to the North
qSamudra Darshan Villas at 6.2 km in the Northeast
qCabana Dempo Villas at 6.5 km in the Northeast
qBambolim beach resort at 6.8 km in the Northeast
qGrand Hyatt Goa at 7.2 km in the Northeast</td></tr>
<tr><td>12</td><td>Biosphere reserves</td><td>None within study area</td></tr>
<tr><td>13</td><td>Defense installations</td><td>INS Hansa - 2.2 km E</td></tr>
<tr><td>14</td><td>Water Bodies/ Reservoirs</td><td>Zuari Estuary abutting</td></tr>
<tr><td>15</td><td>Critically polluted areas as per MoEF notification</td><td>None within study area</td></tr>
<tr><td>16</td><td>Seismic Zones</td><td>Zone III – Moderate Risk Zone as per as per IS1893 (Part1) : 2002</td></tr>
<tr><td>17</td><td>Nearest Industries</td><td>
<table>
<tr><th>S. No</th><th>Name of Industry</th><th>Type</th><th>Distance (km)</th><th>Direction</th></tr>
<tr><td>1</td><td>Goa Shipyard Limited</td><td>Ship Building</td><td>1.5</td><td>East</td></tr>
<tr><td>2</td><td>Western India Shipyard Ltd</td><td>Ship Building</td><td>2.3</td><td>West</td></tr>
<tr><td>3</td><td>Zuari Agro Chemicals</td><td>Fertilizers</td><td>7.5</td><td>Southeast</td></tr>
</table>
</td></tr>
<tr><td>18</td><td>Sand dunes</td><td>Nearest minor beach (Khariwada) is abutting the project site.</td></tr>
<tr><td>19</td><td>Mud flats</td><td>Nearest mud flats are at a distance of about 4km East of the project site.</td></tr>
</table>

S.No.	Particular	Details
20	National parks, marine parks, sanctuaries, reserve forests, wild life habitats, biosphere reserves	Dr. Salim Ali Bird Sanctuary is located about 13 km North
21	Salt marshes	Nearest salt marsh is at about 7 km East of the project site where the mangrove patch occurs.
22	Turtle nesting sites	None within study area
23	Horse-shoe crab habitats	None within study area
24	Sea grass beds	Scanty occurrence of seagrass species Halophila becarii at about 9 km inside Zuari estuary
25	Nesting grounds	Dr. Salim Ali Bird Sanctuary is located about 13 km North

Note: Distances indicated based on aerial measurement

Site Photographs

View of Vasco Bay – Proposed Project Site

Fishing Boats in Vasco Bay

ULTRA-TECH Team during Site Visit

1.5. Need for EIA Study

As per clause No. 7 (e) of Schedule of S.O. 1533 dated 14th September, 2006 of the Ministry of Environment Forests and Climate Change, Govt. of India (MoEF&CC) prior environmental clearance is required for the Port and Harbour projects involving cargo handling, and fish landing of more than 10000 TPA. The landings of marine fish at Vasco bay is more than 20,000 TPA. The cargo handling recorded at this Port was 20.78 million tonnes in 2015-16. Hence it will be considered as Category A and appraised at EAC – MoEF&CC, New Delhi.

As the proposed development will be in a CRZ area, CRZ Clearance from MoEF&CC is mandatory under the CRZ Notification 2011.

Environmental Impact Assessment (EIA) study needs to be conducted as per the guidelines stipulated in the EIA notification of September 2006 and CRZ Notification of January 2011. Hence it is proposed to conduct an EIA study to assess the impacts likely to occur as a result of various activities associated with the proposed expansion and modernization at Mormugao Port. A suitable Environmental Management Plan (EMP) will be prepared based on the impacts identified, to mitigate the adverse impacts. An environmental monitoring plan will also be suggested in this EIA report.

The project was appraised by Expert Appraisal Committee (Infra-2) at MoEF&CC, New Delhi during its 15th meeting dated 12th to 14th April 2017 to grant Terms of Reference for EIA studies.

1.6. Methodology adopted for the EIA Study

Detailed review of the feasibility report for the proposed development has been carried out. Ten km radius of study area was marked using latitudes and longitudes of the project site. For all major environmental components, primary and secondary data was generated and compared with the available historical/published information for assessment of various environmental components to develop the Environmental Management Plan (EMP).

Land use pattern, drainage and contour was mapped within 10 km radius from the proposed project site using remote sensing and GIS tools followed by ground truth verification. Baseline monitoring program was undertaken during March - May 2017 to establish the marine water

qualities, marine sediment quality, soil quality, air quality, ground water and surface water quality and noise levels in the study area.

The AAQ data was collected during March 2017 to May 2017. The average meteorological conditions of the Mormugao were obtained from the observations of IMD Goa from 1981-2010. Ecology and biodiversity studies were carried out for terrestrial and marine components of the study area. The Marine biodiversity impact assessment report and management plan ton marine, brackish water and fresh water ecology and biodiversity was prepared by the National Institute of Oceanography (NIO) Goa. Field Survey was undertaken to develop socio-economic profile of the study area and was compared with published census data for further refinement.

A detailed review on the possible environmental pollutants such as emissions, siltation, liquid and solid wastes were undertaken. Impact Assessment of various environmental components have been carried out using standard EIA tools and techniques with appropriate input of primary and secondary baseline data to determine the significance of the impact. Various activities those are envisaged during construction and operation phases of the proposed project were evaluated for its significance. Based on the impact, suitable EMP was developed to mitigate the probable negative impacts. Oil Spill Contingency Plan and Emergency Response Plan prepared by MPT were also reviewed for the proposed project.

CRZ map indicating the HTL/LTL demarcation, prepared by Institute of Remote Sensing, Anna University Chennai, for the Mormugao Port Trust was reviewed and suitable recommendations have been made in the EIA report.

1.7. Structure of the EIA report

The present EIA Report is organized into ten sections and all relevant aspects as per the guidelines of the MoEF&CC as well as the EIA Notification 2006 and its subsequent amendments thereon, have been addressed in this report.

Section 1 describes the introduction, project back-ground, justification of project site and EIA methodology adopted for undertaking EIA studies.

Section 2 presents the project description of the proposed development plan along with utilities and supporting infrastructure facilities and transportation of manpower.

Section 3 describes the existing baseline environmental conditions of the study area. Various environmental components such as air quality, water quality, noise levels, meteorological data, ecological and biological aspects, marine environment and socioeconomic details have been presented.

Section 4 of the report discusses the residual environment impact during operation of the facility. Environmental Impact Assessment was made using, mathematical model taking in to account the baseline parameters. Based on the findings of the study, site specific Environmental Management Plan has been developed.

Section 5 describes the proposed Environment Monitoring Program to be implemented during construction and operation stages of the proposed project. It also describes post-project monitoring plan to be conducted under various stages and reporting procedures.

Section 6 describes the additional studies such as CRZ study, hydrodynamic modeling, Risk Assessment, Oil Spill Contingency Plan and Disaster Management Plan undertaken.

Section 7 presents the tangible benefits arising from the proposed expansion and modernization at the Mormugao Port

Section 8 deals with Environment Management Plan to be implemented during construction and operation phases to mitigate environmental impacts.

Section 9 includes the Summary of the EIA report.

Section 10 depicts the Disclosure of Consultants engaged for preparing the EIA report.

2. PROJECT DESCRIPTION

2.1. General

The Mormugao Port in Goa, in the West Coast of India, was once known as the premier iron- ore exporting Port of India, but currently, the port is all set to diversify into other commodities. The demand for handling facilities for bulk, general cargo and containers traffic has made capacity addition a priority.

The commodity wise traffic handled at this port from 2012-13 to 2016-17 is depicted in Table 2.1and Overseas/ Coastal Traffic and commodity wise coastal cargo handled by MoPT in last 2 years is given inTable 2.2. and 2.3. The commodity wise traffic forecast for the port from 2016 to 2030 is given inTable 2.4.

Table 2.1: Commodity wise traffic handled at Mormugao Port from 2012-13 to 2016-17

Sl. No	Cargo Details		2012-13	2013-14	2014-15	2015-16	2016-17
Imports							
1	*Liquid Cargo*	POL	0.82	0.52	0.57	0.56	0.63
2		Phosphoric acid	0.16	0.24	0.36	0.37	0.34
3		Caustic soda, Liquid ammonia, Sulphuric acid, Edible oil	0.06	0.1	0.14	0.13	0.11
	Total Liquid Cargo		1.04	0.86	1.07	1.06	1.07
4	*Fertilizers*	Muriate of Potash	0.08	0.15	0.21	0.19	0.18
5		DAP/Urea	-	0.03	0.02	0.03	0.02
	Total Fertilizers		0.08	0.18	0.23	0.22	0.2
6	*Other General Cargo*	Coking Coal	6.61	7.52	6.57	7.81	8.46
7		Thermal Coal	0.77	-	2	3.73	2.51
8		Pet Coke Raw	0.18	0.35	0.43	0.6	0.8
9		Wooden Chips	-	0.39	0.39	0.58	0.37
10		Lime Stone	0.15	-	0.11	0.56	0.81

11		Iron Ore/ Pellets	-	-	0.15	0.39	0.33
12		Container Cargo/ Tare weight	0.14	0.11	0.14	0.21	0.23
13		CP Coke, Bauxite, Met Coke, Nickel products, machinery, Iron & Steel, Bentonite, Miscellaneous, Sugar	0.25	-	0.3	0.21	1.05
	Total Other General Cargo		7.95	8.37	10.09	14.09	14.58
Total Imports			**9.07**	**9.41**	**11.38**	**15.37**	**15.85**
Exports							
14	*Ore & Allied products*	Iron Ore/ Pellets	7.42	0.05	0.6	3.57	14.72
15		Bauxite	0.07	0.15	0.27	0.21	-
	Total Ore & Allied products		7.49	0.2	0.87	3.78	14.72
15	*General Cargo*	HR Steel coils	0.79	1.2	1.63	0.84	1.82
16		Granite	0.19	0.36	0.3	0.31	0.29
17		Pig Iron	-	0.27	0.26	0.31	0.14
18		Container Cargo/ Tare weight	0.11	0.12	0.17	0.14	0.17
19		Iron & Steel, Maize, Miscellaneous, Sugar, Wheat, Calcine d, Aluminia, CP Coke	0.09	0.19	0.1	0.03	
	Total General Cargo		1.18	2.14	2.46	1.63	2.61
Total Exports			8.67	2.33	3.33	5.41	17.33
Grand Total			**17.74**	**11.74**	**14.71**	**20.78**	**33.18**

During the year 2015-16, the Port handled traffic of 20.78 million tonnes as against 14.71 million tonnes handled during 2014-15. The traffic comprised of 5.41 million tonnes of Exports and 15.37 million tonnes of imports. The traffic of 20.78 million tonnes handled during 2015-16 was inclusive of 14.09 million tonnes Thermal / Coking coal and 1.06 million tonnes of Liquid bulk (including 0.56 million tonnes of POL). The other cargo includes iron ore / pellets, limestone, bauxite, steel coils, pig iron and container cargo. The Port has also handled imports of wood chips, which is a major raw material for the paper industry.

Table 2.2: Overseas/ Coastal Traffic

Sl. No.		2015-2016			2016-2017		
		Overseas	Coastal	Total	Overseas	Coastal	Total
1	Imports	14,636	733	15,369	15030	818	15848
2	Exports	5,039	368	5,407	17107	226	17333
3	Total	19,675	1,101	20,776	32137	1044	33181
Percentage to the total		**94.7**	**5.3**	**100**	**96.8**	**3.2**	**100**

Table 2.3: Commodity-wise Coastal Cargo

Sl.No.	Cargo (in tonnes)	2015-16	2016-17
1.	POL	559	618
2.	Iron & Steel	-	38
3.	Iron Ore	210	87
4.	Machinery	-	2
5.	Coking coal	68	117
6.	Raw Pet Cake	41	-
7.	Container Cargo	74	97
8.	Bentonite	4	2
9.	Hot Rolled Coils	145	83
Total		**1101**	**1044**

Table 2.4: Commodity wise traffic forecasted at Mormugao Port from 2016 to 2030

Commodity		2016	2017	2018	2019	2020	2025	2030
Liquid Cargo	POL	0.40	0.40	0.41	0.42	0.42	0.46	0.50
	LPG	0.05	0.05	0.05	0.05	0.05	0.06	0.06
	Phosphoric acid	0.16	0.17	0.17	0.18	0.19	0.27	0.33
	Liquid Ammonia	0.30	0.32	0.34	0.36	0.38	0.53	0.66
Sub Total		**0.91**	**0.94**	**0.97**	**1.01**	**1.04**	**1.32**	**1.55**
Dry Bulk	Iron Ore Export	3.50	3.70	4.00	4.30	4.50	6.50	8.50
	Iron Ore Import	2.00	2.10	2.30	2.40	2.60	3.40	4.60
	Thermal Coal	1.94	4.46	7.21	8.5	8.89	11.33	14.37
	Coking Coal	10.8	12.1	13.2	14.5	15.8	24.3	36.7
	Fertilizer	0.32	0.33	0.35	0.36	0.37	0.43	0.74
Sub Total		**18.56**	**22.69**	**27.06**	**30.06**	**32.16**	**45.58**	**64.91**
Break Bulk		4.75	5.14	5.55	5.98	6.43	9.12	12.38
Containers		0.36	0.41	0.46	2.14	2.28	3.09	4.23
Total		**24.58**	**29.18**	**34.04**	**39019**	**41.91**	**59.49**	**83.07**

From these tables, it is obvious that capacity addition is inevitable at Mormugao Port.

2.2. Description of the Existing Facilities

2.2.1. Approach Channel

The Port of Mormugao has a 250 m wide channel that is 6.8 km long in the Outer Channel from A1 zone up to the Turning circle 1 and 0.67 km long in the Inner Channel up to the Turning circle 2. The depths range from 14.1 m in the Inner Channel to 14.4 m in the Outer Channel. Beyond Berth No. 9 (iron ore berth), the channel including turning circle 2 and mooring areas

shoal, the depth is 13.1 m. The channel is one way navigation channel. The approach channel has the following characteristics:

Turning Basins: 2 nos. of 480 m diameter

Tidal Range: Springs- 2.3 m/ Neaps-1.0m

2.2.2. Breakwater

The port has a 522 m long breakwater aligned slightly east of north at the western end of the port. A mole of 270 m long runs from the tip of the breakwater. The breakwater and the mole give protection to the berths from West and North-West waves during monsoons.

2.2.3. Berthing Facilities

As on today there are 11operational berths at the Mormugao Port. The details of these berths in terms of the dimensions and the type of cargo handled are given in Table 2.5 and Table 2.6 and Location plan of the berths are given in the Figure 2.1.

Table 2.5: Existing Berthing Facilities at Mormugao Port

Sl.No.	Berth No.	Length (m)	Depth (m)	Capacity (in MTPA)	Cargo/ Usage
1.	1,2,3	-	-	-	Ship repair
2.	4	194	8	-	Port Craft Jetty
3.	5	210	13.1	-	Coal, Coke, Gen. Cargo
4.	6	240	14.1	7.50	
5.	7	300	14.5	5.20	Coal/Coke
6.	8	298	13.1	1.50	Liquid Bulk
7.	9	357.50	14.1	11.50	Iron Ore
8.	10	550	13.1	2.65	Gen. Cargo
9.	11				
10.	6 Nos. MDs	340	14.1	10.00	Iron Ore/Coal
11.	TVs	6 No’s		6.00	Iron Ore
12.	Cruise Berth	450	9.50	-	Cruise Vessels

Sl.No.	Berth No.	Length (m)	Depth (m)	Capacity (in MTPA)	Cargo/ Usage
13.	Mole Berth	250	9.50	-	Defence Vessels
	Total			**44.35**	

Table 2.6: Berth wise details and size of the vessels proposed to call

Sl.No.	Berth No.	Type of the Berth	Length (m)	Size of the Vessels	
				Length overall	DWT Approx.
1.	1,2,3	Shipyard	-	-	-
2.	4	Non-Cargo berth	194	190	-
3.	5	General Cargo	210	190	50000
4.	6		240	225	70000
5.	7	Coal Cargo	300	300	160000
6.	8	Liquid Bulk	298	260	125000
7.	9	Iron Ore	357.50	335	275000
8.	10	General Cargo	250	225	55000
9.	11		270	225	65000
10.	6 Nos. MDs	Iron Ore/Coal	340	225	70000
11.	TVs	Iron Ore	6 No’s	-	-
12.	Cruise Berth	Non-Cargo berth	450	-	-
13.	Mole Berth	Non-Cargo berth	250	200	-

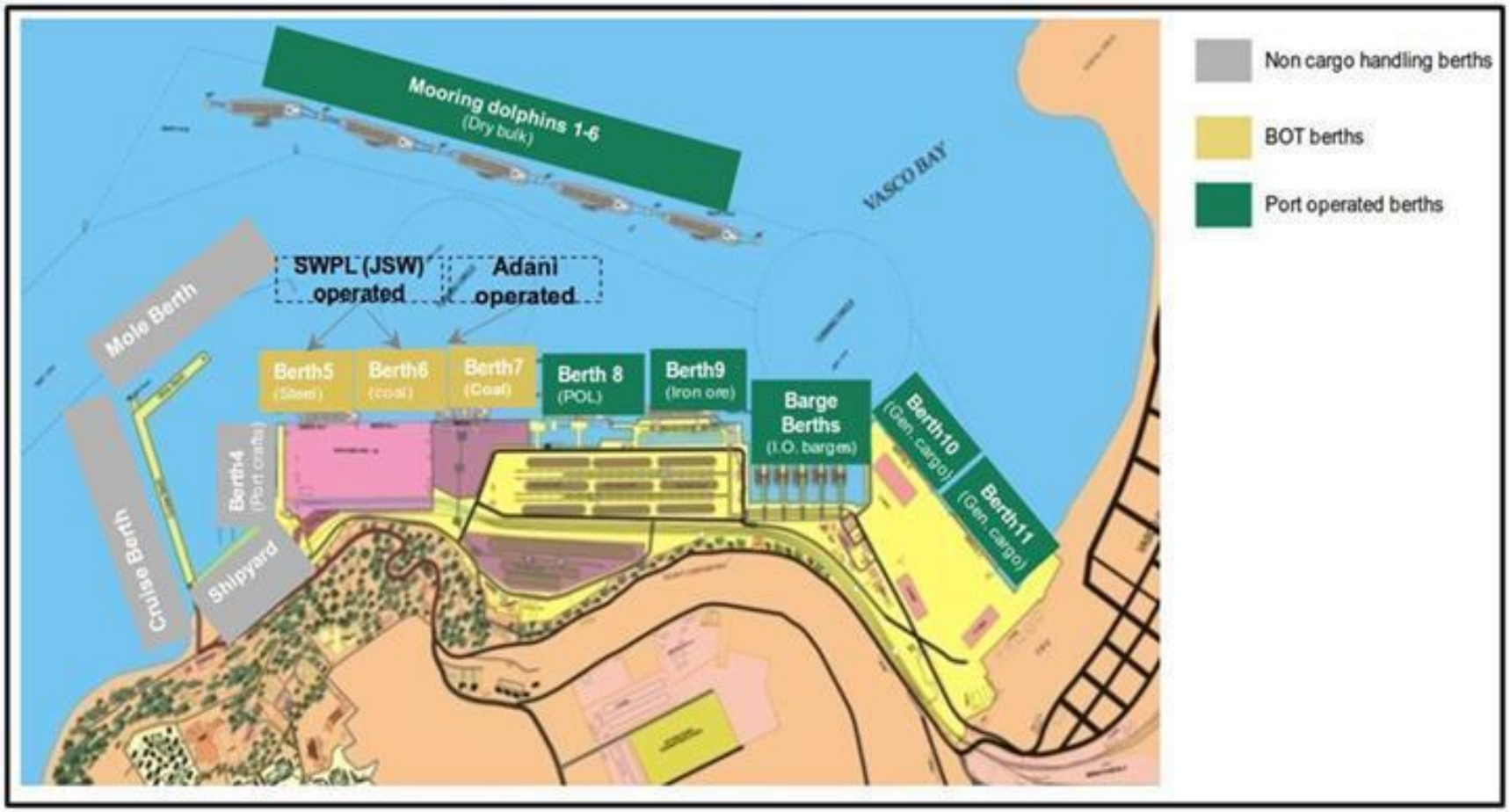


Figure 2.1: Existing Berthing Facilities at Port

2.2.4. Storage Facilities

The Storage facilities at Mormugao Port comprise of covered storage area in the form of transit sheds, warehouses and open storage area and tanks for liquid cargo area.

2.3. Description of the Proposed Modernization and Expansion

Sagarmala project is a strategic and customer-oriented initiative of the Government of India to modernize India's Ports. It looks towards "transforming the existing Ports into modern world class Ports and integrate the development of the Ports, the Industrial clusters and hinterland and efficient evacuation systems through road, rail, inland and coastal waterways resulting in Ports becoming the drivers of economic activity in coastal areas. Under SagarmalaProgramme, 415 projects, at an estimated investment of approximately INR 7.98500 lakh crore have been identified across port modernization & new port development, port connectivity enhancement, port-linked industrialization and coastal community development for phase wise implementation over the period 2015 to 2035. The proposed modernization and expansion at Mormugao Port comes under the Sagarmala project. A total marine reclamation work of about 85195m^2 is involved. A total dredged quantity of about 15,05,660m^3 is involved.

Mormugao Port Trust (MPT) proposes following Modernization and Expansion of the Port Infrastructure at Mormugao.

- Construction of Fishing Jetty.
- Development of Berth for Liquid bulk (Petroleum products including LPG) and other General Cargo.
- Development of Multipurpose Cargo Berth.
- Construction of Passenger Jetty, Launch Jetty, and Port Craft Jetty.
- Deepening of Berths 10 & 11 pockets from -13.10 to -15.0 m.
- Deepening of Breakwater Berth from -9.5 to -11.5m

Each of the above proposed facilities are explained in detail in the following sections and Master plan layout of the proposed Modernization/ Expansion of the MoPT is given in theFigure 2.2. Layout superimposed on google image is attached as ***Annexure I***.

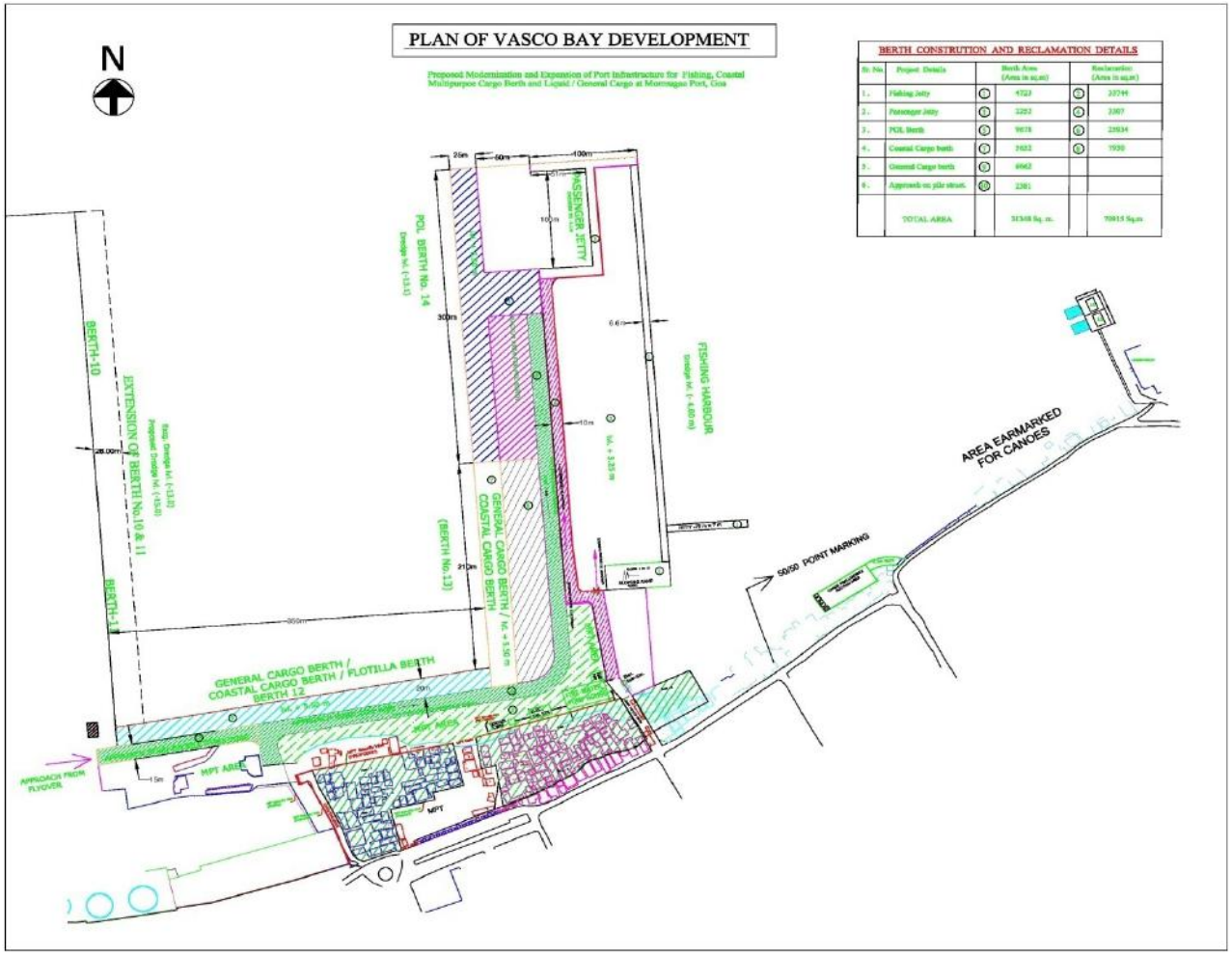


Figure 2.2: Layout of Proposed Port Developments

2.3.1. Construction of Fishing Jetty

Fishing activities within Vasco Bay is one of the major limitations for expansion of the Mormugao Port. It is therefore, proposed to construct fishing jetty along with allied facilities. Existing facility is a temporary fish landing platform which is inadequate considering the number of trawlers operating from Vasco Bay.

The Goa Boat Owner's Association has been demanding a fully fledged jetty for landing of their catch. Besides, the fishing jetty being close to MPT berths, trawlers venture very close to the merchant ships which are a serious safety as well as security hazard. As Mormugao Port is ISPS compliant it is difficult to maintain such situation in long terms. It is therefore proposed to shift existing fish landing platform to another location.

A Fishing Harbour is a place where the fishing boats are assured safety while in operation or idling. It should be possible to load / unload the contents with minimum handling and within shortest possible time. The basic facilities to be provided are broadly divided into two categories viz., Waterside facilities and Landside facilities.

Waterside Facilities

- Proper access to the landing center from the sea
- Outfitting Quay and berthing quay
- Navigational Aids etc.

Landside Facilities

- Security
- Auction Hall
- Administrative building
- Rest shed
- Net mending shed
- Gear shed
- Ice plant
- Equipment and operating rooms

- Access roads
- Slip way complex
- Workshop
- Toilet
- Canteen
- Radio Communication Centre
- Fuel, Electric & Water Supply, etc.

Planning of Waterside Facilities

(i) Fishing Vessel Characteristics

The fisheries harbour has to cater to the needs of fishing trawlers, mechanized as well as motorized / country boats. The vessel characteristics are the overall length, beam and draught of the vessel in loaded condition. The information gathered on the draft of the fishing vessels in general vis-a-vis the maximum LOA and the beam of the vessels operating at the harbour is:

x Fishing Trawlers LOA - 22m
x Beam - 7.20 m
x Draft (in loaded condition) - 4.00 m
x Fleet in nos. in Vasco bay - 250

(ii) Fish unloading

Fish catch can be unloaded at the quayside by a various means like manual harbour,scooping, containers, mechanical conveyors, fish pumps, etc., For the present case, it is proposed to handle fish manually at an unloading rate of 4500 kg/hr in basketsor containers boxes. As soon as the fishing vessels arrive, fish is shoveled from thefish holds of the boats into baskets or boxes of 25 to 50 kg.

Water Depth Requirement:

The area in front of the proposed landing facility should be deep enough even during low waters so as to accommodate the fishing trawlers whose maximum draught requirement in fully loaded condition is 4.0 m.

Berth Requirements

(a) Quay Length

In a fisheries harbour, quays are constructed for various purposes like fishlanding/berthing, outfitting and idle berthing of fishing boats/net drying area.

(b) Berthing Quay Length

The Landing/ Berthing quay length is a function of various parameters such asvessel – length, duration of fishing trip, time required for docking / undockingof vessel, quantity of fish catch, rate of unloading the fish catch etc., the important assumptions made in computation of quay length. 10% of the fishing fleet may not go out for fishing due to maintenance, repair or some other reason.

During peak season, 40% of motorized boats on one-day trip may arrive in an hour with 20% increase in fish catch. A uniform manual unloading of 4500 kg/hr is assumed for both type of fishing boats. Permissible duration of fish landing by fishing boats and outfitting these boats are reasonably assumed to be 6 to 10 hours respectively.

The landing quay length for a fishing vessel consists of the overall length of theboat in their category plus a free spacing of 10% of its overall length betweenthe boats to facilitate safe maneuvering.The landing quay length proposed is 316m.

(c) Outfitting Quay

The outfitting quay length is a function of parameters such as time required for docking/undocking of vessel, outfitting period, etc,. The important assumptionsmade in the computation of quay length are:

10% of the fishing fleet may not go out for fishing due to maintenance, repair or some other reason. Time taken on an average by each vessel for this reason is assumed to be 15 min. The outfitting quay length proposed is 75 m.

(d) Berthing Quay / Net Mending Area

Fishing Vessels when not on fishing trip are idle berthed in the harbor alongside this area. During idle berthing, four vessels lie abreast / one vessel with nose berthing arrangement alongside the berthing face. In the proposal,this area has been earmarked for net drying. The berthing quay lengthproposed is 75 m.

(e) Technical details on quays

The proposed quays will be of concrete structure with beams & deck slabsupported on bored cast in situ RC piles of 760 mm dia (provisional) and the topdeck slab of 30cm depth. Proposed to provide 5T pull bollards at a spacing of 20 m c/c proposed to provide wooden fenders horizontally along the berthingface.

(f) Slip Way Complex /Boat Repair Yard

The fishing trawlers and motorized fishing vessels need occasional repairs oftheir engine and other parts onboard while they remain idle. Keeping this inview, a boat repair yard along with a slipway complex of size 30 X 50 m hasbeen proposed south of the outfitting quay. The motorised boats being light inweight can also be pulled out of waters and serviced on the land opposite tothe boat repair yard.

(g) Deck level of Quay

The criteria for fixing the top level of the landing/berthing quay is that it shouldfacilitate easy unloading of fish baskets / boxes by manual labour during meanhigh waters of springs. Similarly, it will be very difficult for the boats to unloadfish alongside the quay at mean low waters of springs, if the top of the quay ismore than a man's height from the deck level of fishing vessel. Keeping in viewthe requirement of fishing trawlers and mechanised boats and the prevailingtide levels, the deck level of the fish landing/berthing quay & outfitting quay is placed at RL +3.25 m.

(h) Utilities proposed in the fisheries harbor

The proposed development area for the fisheries harbor is around 33,744 m^2. This area comprises of jetty area, backup area, slipway area and area nearapproach. In the above proposed development area the utilities such assecurity cabin, office & radio communications, auction hall, canteen, rest shed,net mending shed, gear shed, ice plant, equipment & operating rooms, petrolpumps and toilets. A separate road of 12 m width along with gate complex hasbeen proposed for the fisheries harbor with exclusive approach to the commercial area through the rehabilitation area. Necessary provision has been made in the block cost estimate for the development of utilities. A security wallhas been proposed to be executed by Mormugao port between the proposedfisheries harbor and the proposed port developmental area on the west side ofthe fisheries harbor.

In this process of development in Vasco Bay, it is proposed to build acompound wall around theresidential area of fishermen on Southern shore of theproposed developments as a security measures.

Dredging

In the Fisheries Harbour area, the dredge level of (-) 4.0 m has been consideredincluding required under keel clearance. At present, the water depth available is2.50m (average). Out of the total dredge material in the above area, about 25% isconsidered to be suitable for reclamation.The dredging quantity is about 1,00,000 m^3.The balance dredged material and the unsuitable dredged material will have to bedisposed of in the designated spoil ground to be earmarked by Mormugao Port.

The layout of the proposed fishing jetty is given in Figure 2.3 and cross section of design is given in Figure 2.4.

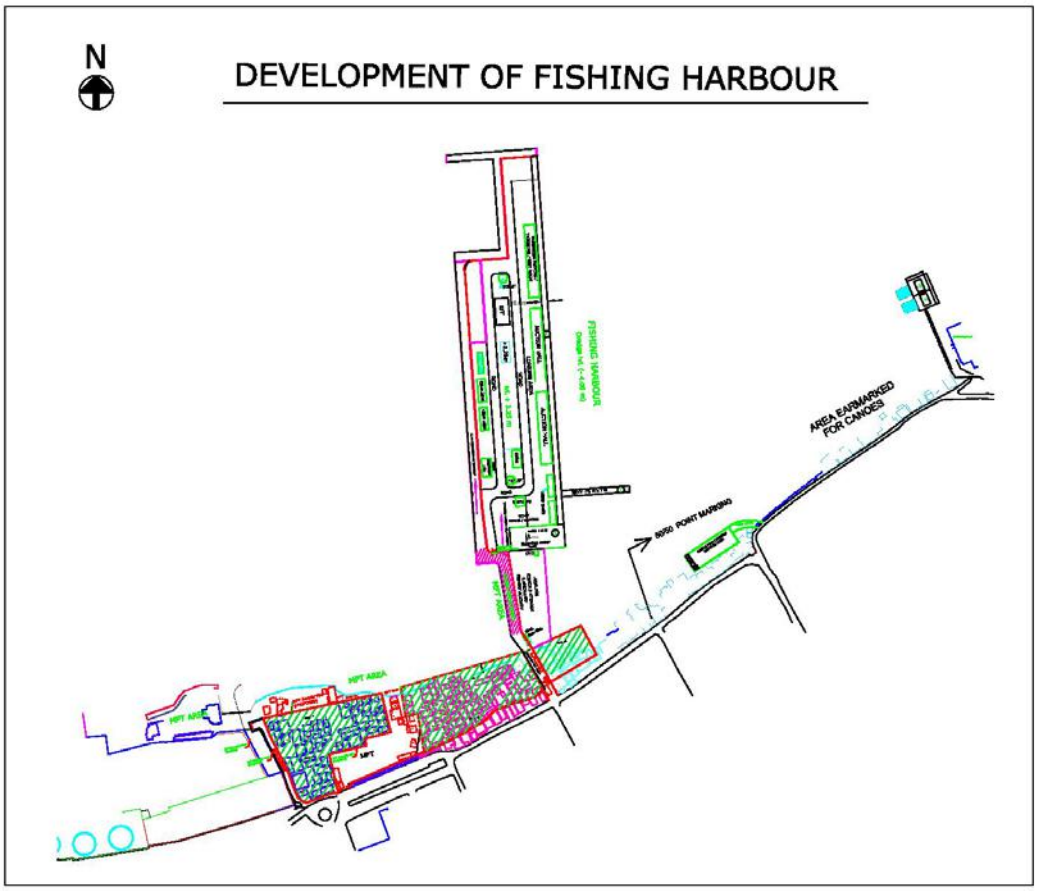


Figure 2.3: Layout of Fishing Jetty

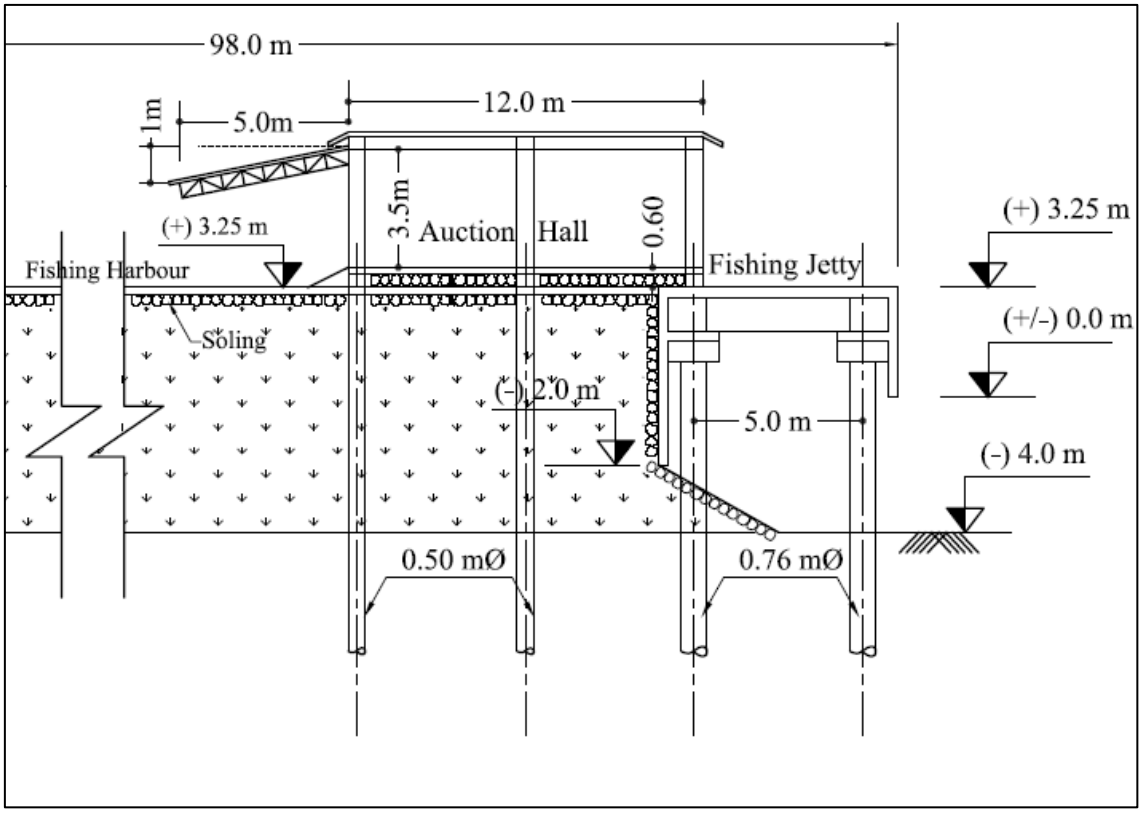


Figure 2.4: Design Cross Section of Fishing Jetty

2.3.2. Construction of Passenger Jetty

A Passenger quay with the basin is a place where the passenger boats are assured safety while in operation or idling. It should be possible to embark/disembark the passengers with minimum inconvenience and within shortest possible time. The basic facilities to be provided are broadly divided into two categories viz., Waterside facilities and Landside facilities.

Waterside Facilities

- **x** Proper access to the landing quay from the sea
- x Passenger Landing Quay
- x Navigational Aids etc.

Landside Facilities

- **x** Security
- x Administrative building
- x Access roads
- x Toilet

x Refreshment stalls

x Waiting rooms

x Parking area

x Battery charging place for charging batteries belonging to the ferries

x Fuel, Electric & Water Supply, etc.,

x Sewage disposal system for sewage that comes from big launches

Planning of Waterside Facilities

(i) Passenger Vessel Characteristics

The quay length, channel and harbor basin area requirement of the proposed passenger landing facility has to cater to the needs of public service vessels like catamarans, launches, speed boats and also for private service vessels of small to medium sizes. The ship chandlers use launches, speed boats etc, for transporting goods and provisions, etc, to the ships. The proposed passenger landing facilities has to cater to the needs of ship chandlers too. It is therefore important to know the characteristics above vessels.

(ii) Design fleet size

The characteristics of the design passenger vessel operating at the harbour are considered as follows.

x Vessel LOA 36 m

x Beam 8 m

x Draft 2.5 m

(iii) Quay length

The landing quay length is function of various parameters such as vessel length, duration of trip, time required for embark/disembark from the vessel, no. of passengers and rate of trips etc.

Accordingly, Passenger landing facility has been proposed with a quay length of 322 m including length of quay required for Passenger Jetty, Launch Jetty and Port Craft Jetty.

(iv) Crest Height of Quay

Keeping in view, the characteristics of the vessels and the proposed crest height of the adjacent proposed fisheries harbor at southern side, the crest height of the quay is placed at the same + 3.25 m.

(v) Technical details on quay

The proposed quay will be of concrete structure with beams & deck slab supported on bored cast in situ RC piles of 760 mm dia (provisional) and the top deck slab of 60 cm depth. Proposed to provide 5T pull bollards at a spacing of 20 m c/c and proposed to provide wooden fenders horizontally along the berthing face. The proposed development area for the passenger jetty is around 3307 m^2.

(vi) Dredging

In the Passenger Jetty area including the basin of size 100m X 100m, the dredge level of (-) 5.10 m will suffice including the required under keel clearance. At present, the water depth available is 2.50m (average). The approximate dredging quantity is 20,000 m^3. Out of the total dredge material in the above area, about 25% is considered to be suitable for reclamation. The balance dredged material and the unsuitable dredged material will have to be disposed of in the designated spoil ground to be earmarked by Mormugao Port.

Layout of proposed passenger jetty is shown in Figure 2.5 and cross section of design is shown in Figure 2.6.

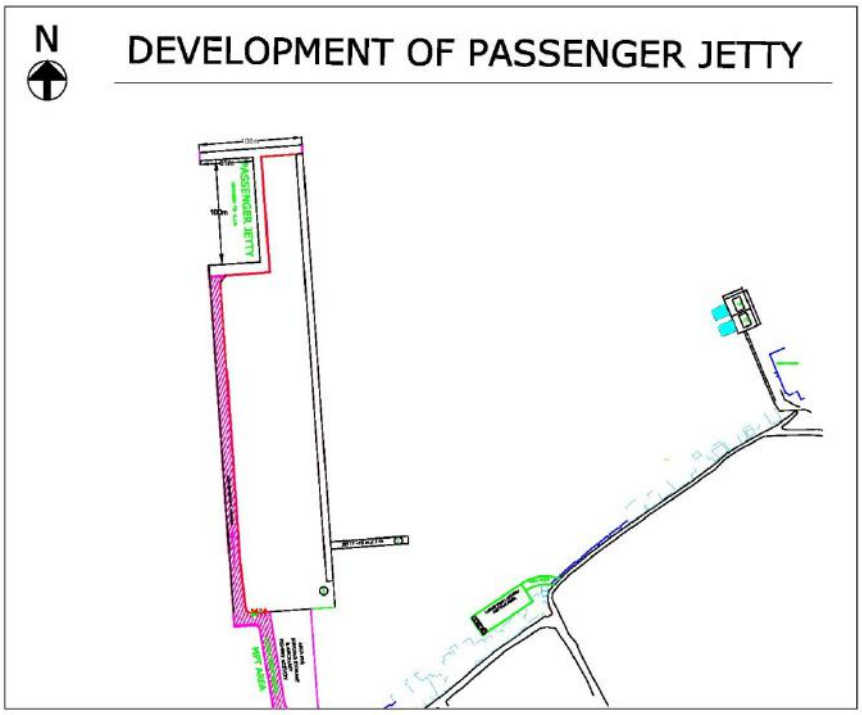


Figure 2.5: Layout of Proposed Passenger Jetty

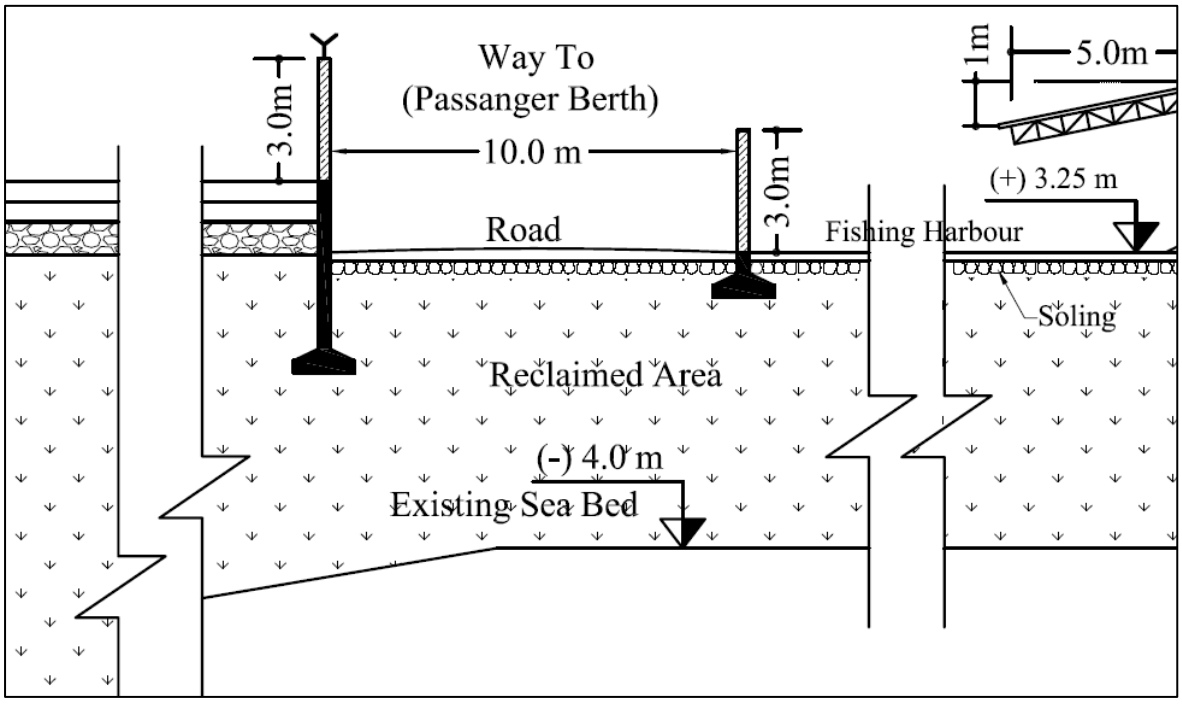


Figure 2.6: Design Cross Section of Passenger Jetty

2.3.3. Construction of Liquid Cargo Berth

Need for Dedicated Liquid Cargo

Presently Liquid cargo is handled at Berth Nos. 8, 10 and 11. Berth 8 handles variousliquid cargoes viz. Caustic soda, Furnace oil, HSD, Liquid Ammonia, Motor Spirit,Palm oil etc. These products are received in smaller tankers with low parcels sizes.

The unloading is done with ship's pumps and hence the average productivity at thisberth is very low i.e. about 9000 TPD only. The capacity of the berth is stated to be 2.2 MTPA with about 70% occupancy. The berth occupancy of this berth in 2014-15and 2015-16 is only 26%.

Berth 10 and 11 handle Liquid cargoes like Aviation oil, HSD, Furnace Oil, LSHF, Kerosene and Phosphoric acid etc. The above cargo is besides the General cargo which is predominantly handled at these berths. The total cargo handled at these berths in 2015-16 is 2.64 MMTs. The Berth occupancy of these berths in 2014-15 is81% & 79% and in 2015-16 it is 67% & 68%. Going by the norms, these berths are over utilized in 2014-15 and utilized optimally in 2015-16. By withdrawing the Liquid cargo handling from these berths the utilisation / occupancy can be at optimal and can be utilized for handling other general cargo.

Berth 8 and 9 are being handed over to a PPP operator for redeveloping and cargo handling due to which the POL cargo being handled at Berth 8 has to be shifted to other berths which is Berth10 and 11 only. As is stated above, Berth10 and 11 are being over utilized and hence there is no other alternative left for the port to develop a POL / Liquid cargo berth to handle the Liquid cargo.

Planning for POL Berth

It is proposed to have a POL Jetty of capacity 2 MTPA in the Vasco Bay. The Feasibility Report for development of Vasco Bay specifies the design vessel size for POL cargo as 85,000 DWT by taking cognizance of the present sizes of the ships which arrive at the Port and the likely trend in the future. The vessel size for POL cargo is considered as 85,000 DWT with the following ship characteristics:

- x LOA - 260m
- x Beam - 38.1m
- x Draft - 14.0m

The POL berth is proposed to be provided with the following components

- Berth structure supported on piles and R.C.C deck of area 300 x 25 m and service platform of approx.. size of 45 x 50 mtr size .
- Fenders and mooring bollards for safe berthing and mooring of ship
- Dredged depth of (-) 13.10 m
- A 3 m high security wall separating Fisheries harbour from the POL/Coastal Cargo Berth

The jetty head will be installed with marine loading& unloading arms for various POL products to be handled. The object of proposing the POL berth/Jetty adjacent to the coastal berth is to leave out eastern space of Vasco Bay for developing fishery harbour and related ancillary facilities. Both these berths are proposed parallel and opposite to berths 10 & 11.

As regards the slip distance between the existing Berths 10 & 11 and the proposed berth, the same is governed by the beam of the largest vessel to be handled. The PIANC guidelines stipulate a distance of 7B (B refers to beam of the vessel) for such, two ships berthing pier configuration. Taking the largest beam to be closer to 40m, a slip of 300m is found adequate so that Port will have sufficient eastern space of Vasco Bay for developing fishery harbour, related ancillary facilities and for future developments. However, a slip distance of 350m is proposed leaving a provision of about 25m for future expansion / strengthening of the existing Berths 10 & 11, if required for future development.

A minimum ship to ship clearance of 90-100 m is to be maintained between the POL vessel and the vessel to be berthed at Coastal Cargo berth. An approach of 15 m width(Approach Trestle and Road) is proposed to connect with the jetty head to lay the transfer pipelines to be taken to the shore and also for transport purposes during installation and operation. Sufficient space has been proposed at the Northern end of the approach jetty for the installation of electrical facilities and fire fighting appurtenances. The POL handling rate can be taken as 1000 tons per hour for all vessel sizes. When the jetty is to be designed for higher DWT vessels, the jetty configuration may be provided with additional mooring dolphins with suitable dredge depth in front.

A security wall separating the activities of Fisheries harbor from the POL and Coastal Cargo berth is proposed with 3m high and top covered with spiral fence along the entire periphery of the fisheries harbour.

Structural Arrangement of Liquid Cargo Berth

Berth structure supported on piles and R.C.C deck of area 300 x 25 m and service platform of approx.. size of 45 x 50 mtr size .An approach corridor / road way of width 15 m is proposed (partially as trestle on pile sand partially on the filled up earth east of Coastal cargo berth) connecting the southern portion of Vasco Bay with the proposed berth for movement of vehicles and routing of pipelines in duct. This approach trestle structure is of concrete with beam and deck slab supported on bored cast in situ RC piles of 1200 mm dia (provisional).

Berth facilities

The berthing dolphins and the mooring dolphins will have the following facilities

- Fenders for berthing - berthing dolphins: 3 fenders on each berthing dolphin
- Bollards for berthing in mooring dolphins: 1 Bollard of 150 tons pull on each mooring dolphin
- Fire, Safety & Pollution Control system
- The proposed development area for the POL Berth is around 25,934 m^2.

Dredging

At present, the water depth at the proposed berth area (POL berth) is (-) 2.5m (average). The Dredge depth of (-) 13.10 is proposed to be maintained in front of berth. The dredging quantity is about 4 lakhs cu m. Out of the total dredge material about 25% is considered to be suitable for reclamation. The balance dredged material after reclamation and the unsuitable dredged material will have to be disposed of in the designated spoil ground to be earmarked by Mormugao Port.

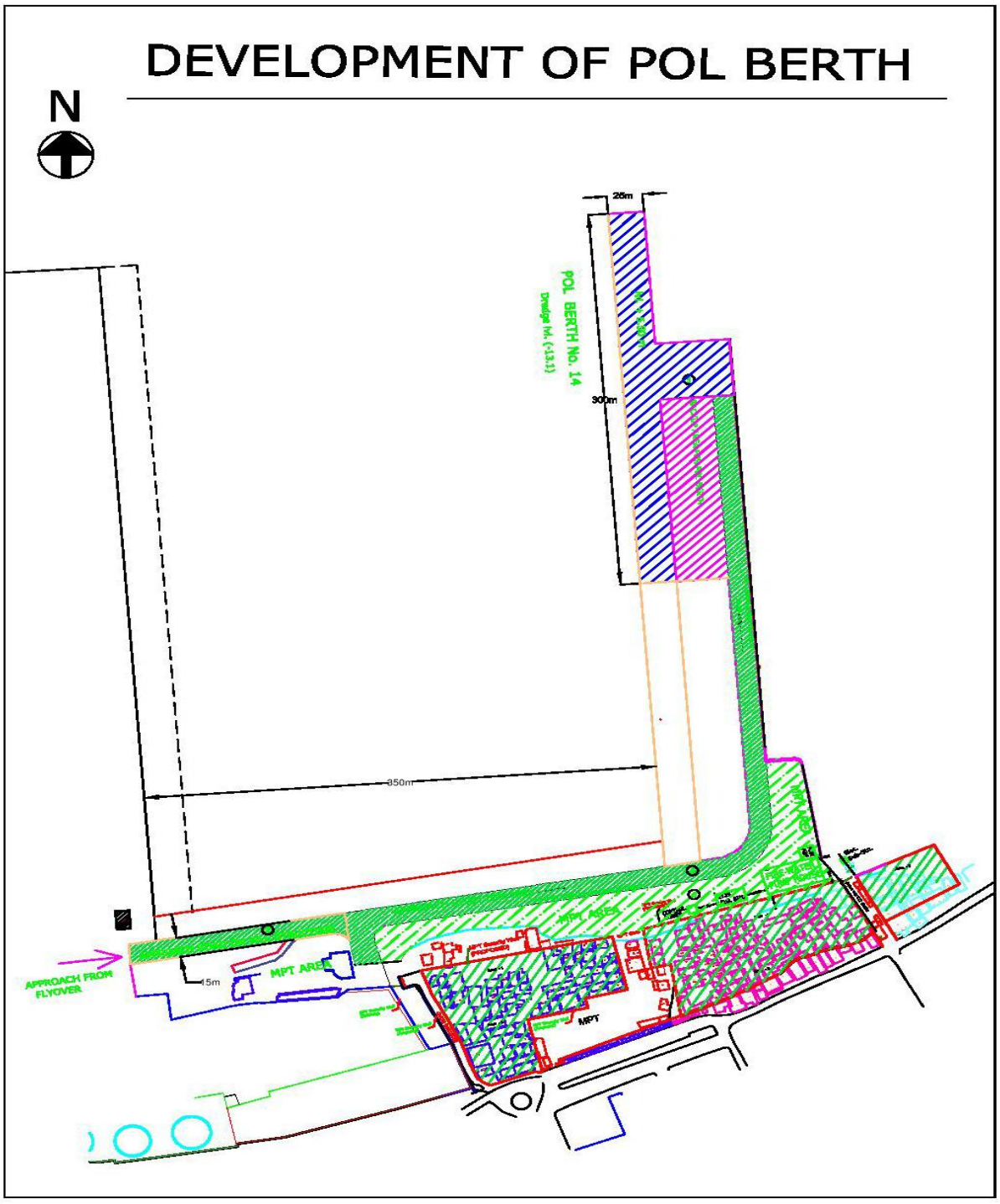


Figure 2.7: Layout of Liquid Cargo Berth

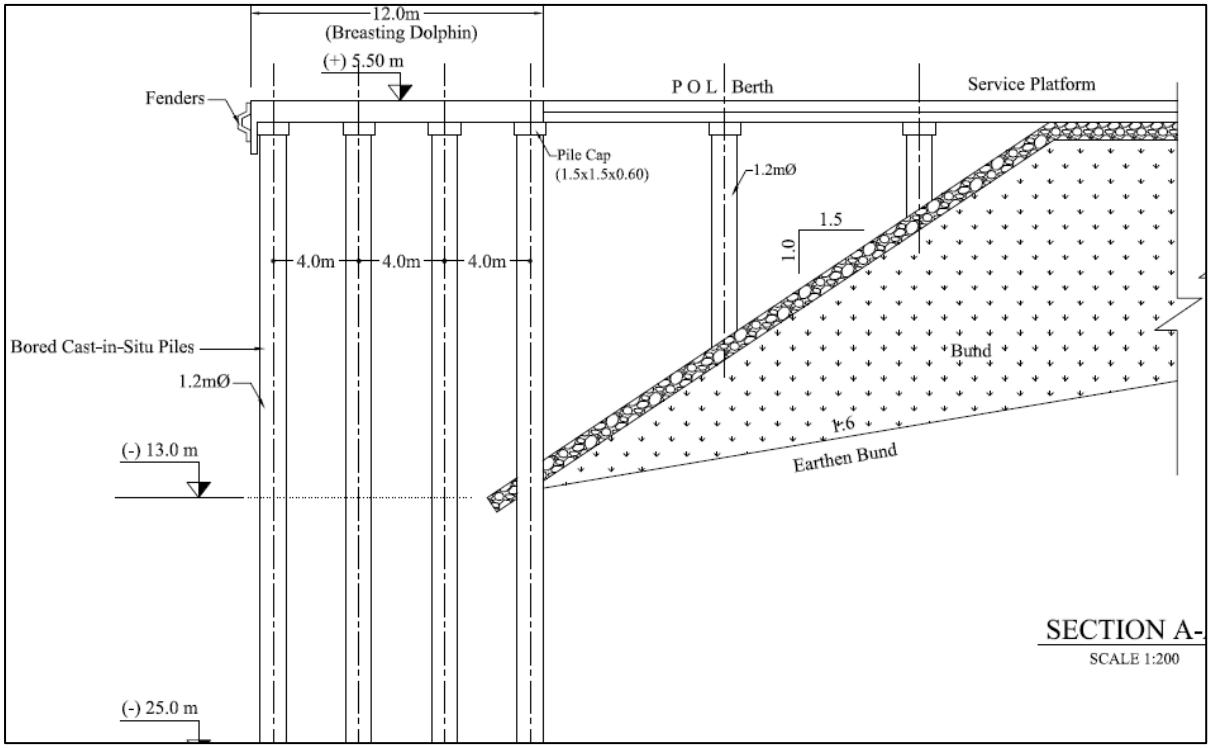


Figure 2.8: Design Cross Section of Liquid Cargo Berth

2.3.4. Development of General and Costal Cargo Berth

The general / break bulk / bulk cargo handling needs of the Port is being met in other berths and also in Berth 10, where the POL products for M/s. IOCL also being handled. A Coastal Cargo berth capable of handling general cargo / break bulk and even at times feeder container vessels upto1000 – 2000 TEU capacity is envisaged. In addition, it is envisaged that the return wharf area between berth 11 and the proposed Coastal cargo Berth could be used as a berthing facility for handling General Cargo with the available back up area and cruise vessels depending on the size of the vessel, availability of vessels in berth 11 & Coastal Cargo Berth, the manoeuvrability conditions and the study on the manoeuvrability.

However, the maximum vessel size of 50,000 – 60,000 DWT with 235m LOA, is considered for planning of Coastal Cargo Berth with the capacity of the berth as 2.00 MTPA. The draft at this berth can be taken initially to -13.1 m and later to -15.0m.

The coastal cargo berth size 210 m x 25 m is proposed to be constructed as open type pile-deck system for Coastal Cargo Berth. And a General cargo berth of size 350 x 25 m is proposed to be constructed as open pile deck system. An effective back up area of 0.79 ha (7,930 sq.m.) is proposed due to space constrain, for handling and movement of the coastal

cargo as discussed with MPT officials, without customs formalities. However, the Indian Standard 4651 prescribes a backup area of 2.5 to 3.0 hectare for a general cargo berth.

The central area is to be filled up with dredged materials and finished at top with paver block to handle general cargo including containers. The traffic from coastal cargo berth is to be evacuated by road. Harbour Mobile Crane one (1) no of capacity 60 T, pay loader one (1) of 10 T capacity and forklift truck one (1) no. of 5T capacity are proposed initially to take care of loading / unloading operations at the Coastal Cargo Berth. The deck top level is maintained the same as POL berth i.e. + 5.50 m CD.

The Return Wharf with the deck level as same as +5.5m CD, along the south side of the shore between the berth 11 & the proposed Coastal Cargo Berth which could be used for handling General Cargo/Cruise Vessels is of about 351m long and the Width proposed as 25m.

Dredging

At present, the water depth at the proposed berth area i.e. Coastal Cargo berth is (-) 2.5m (average). Initially a dredge depth of (-) 13.10 is proposed to be maintained in front of the proposed berth. The dredging quantity is about 3,40,000 m^3 for Coastal Cargo berth and 1.40 lakhs m^3 for General cargo Berth. Out of the total dredge material in the above two areas, about 25% is considered to be suitable for reclamation.

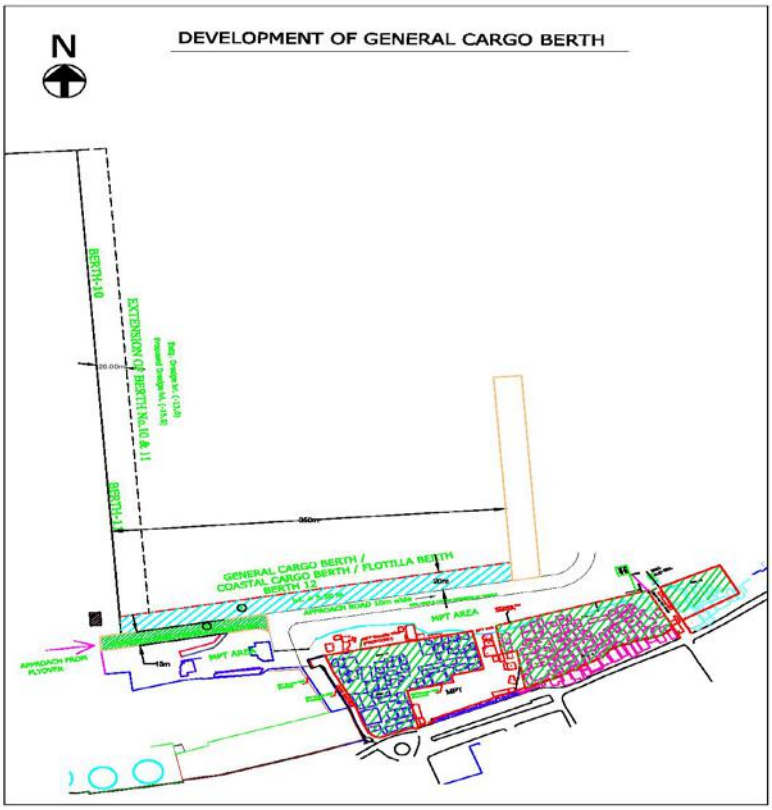


Figure 2.9: Layout of Coastal and General Cargo Berths

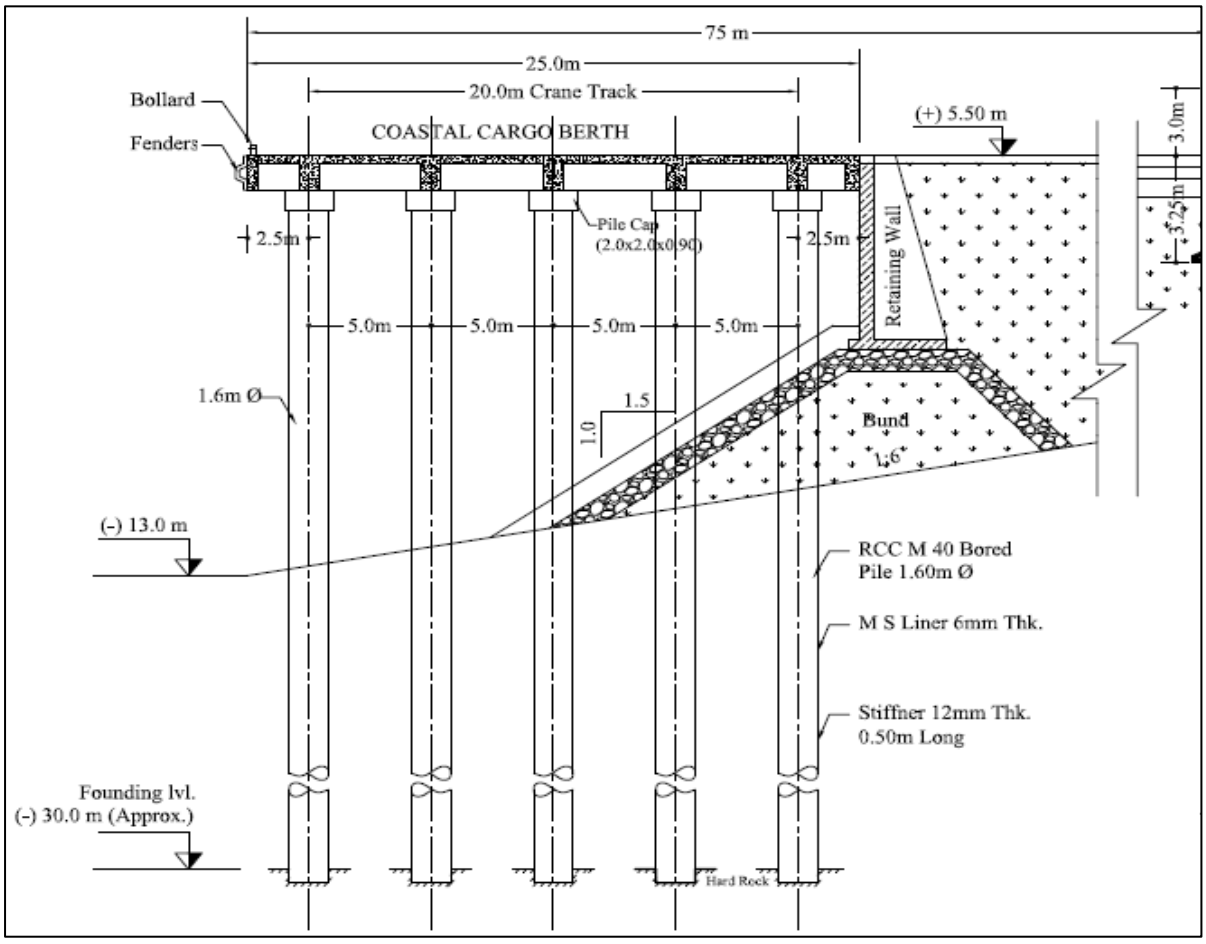


Figure 2.10: Design Cross Section of General and Coastal Cargo Berths

2.3.5. Deepening of Breakwater Berth

The existing breakwater berth was constructed in the year May 2012 exclusively for berthing of cruise vessels of a max. draft 9.5m. In the recent shipping sector the higher size cruise vessels are calling on this Port which makes it difficult to berth at Breakwater Berth. Goa being promoted as a tourist destination all over the world Mormugao Port shall have to cater for increase in draft of the berth to accommodate ships of higher drafts. Considering the demand of the stakeholders it is proposed to deepen Breakwater berth. Also the level of the breakwater is found to be at (-) 9.00 m. Hence in order to facilitate the deepening, sheet piling at the edge of the berth will be driven from a depth of (-) 9.00 m to a founding level of (-) 20 m. Deck slab will be designed to take machinery for cargo handling capacities.

2.4. Use of Natural Resources in the Construction and Operation Phases

2.4.1. Land

The project does not involve any change in land use as all constructions are proposed on reclaimed marine area within the Port Basin under Mormugao Port Jurisdiction. The item wise land resource utilization including the requirement of reclamation/capital dredging is given in **Error! Reference source not found.**. A total marine reclamation work of about 85,195m^2 is involved. A total dredged quantity of about 15,05,660m^3 is involved.

Table 2.7: Land resource utilization/ Capital dredging/ Reclamation requirement

S No	Proposed Development Activity	Land resource requirement/Requirement of reclamation/Capital Dredging
1	Construction of Fishing Jetty	Land required for shore based facilities like auction hall, loading area, parking area, approach road, internal roads, net mending shed, gear shed, rest shed, ice plant cum chilled storage facilities and administrative office. For these a total area of 33,744 m^{2}is proposed to be reclaimed.
2	Development of berth for liquid bulk (Petroleum products including LPG).	A Berth of length 300 m and a connecting approach road of 650 m in length and 15 m in width is proposed to be constructed. The total back- up area of both berths shall be approximately 25,934 m^2
3	Development of Berth for Coastal and Multipurpose Cargo Berth.	Coastal Berth of length 210 m and Multipurpose Cargo Berth of length 350 m. A backup earthen bund for reclamation is also proposed. The total back- up area of both berths shall be approximately 7930 m^2 to cater to storage and handling of general and

		coastal cargoes
4	Development of Passenger Jetty, Launch Jetty, and Port Craft Jetty	A Passenger jetty of size 100 m X 8m, Launch jetty of size 100 m X 8m and Port Craft Jetty of size 61 m x 8 m. (All are proposed RCC structures). Reclamation work of 3307 m^2, Capital Dredging of 20,000 m^3
5	Deepening of Berths 10 & 11from -13.10 to -15.0m. (including the cost of strengthening)	Strengthening of Berth No. 10 & 11 will consists of projection of existing deck slab by 26m in water area supported on piles and reclamation work of 14800 m^2
6	Deepening of Breakwater Berth from -9.5 to -11.5m (including the cost of strengthening)	In order to facilitate the deepening, sheet piling at the edge of the berth will be driven from a depth of (-) 9.00 m to a founding level of (-) 20 m

2.4.2. Water Requirement

During project construction and operation phases, water would be required for meeting various needs. During construction phase, about 20 m^3/day of water will be required for meeting domestic water demand as given below:

- Water for workers at the project site @ 50 lpcd for 70 persons – 3.5 m^3/day
- Water required for construction and allied purposes is about 16.5 m^3/day

During operation phase major water intensive activity will be fishing harbor. About 140 m^3 of fresh water will be required to meet the demands of fishing boats, domestic use, cleaning of fish, etc. Water demand is calculated considering fish landing 20,000 TPA with 300 fishing days. Approx. 500 people will be present in fishing harbor. Seawater will also be used as firewater on liquid cargo berth.

Table 2.8: Water Requirement for Fishing Harbour

(a) Total Water Requirement for cleaning			
Fish washing (1 KL/T)	66.67 TPD	Approx.	70 KLD
Cleaning of Auction hall (5lit/m^2)pressurized	2880 m^2	Approx.	15 KLD
Fish box washing 10 lit/box/day	1725 boxes	Approx.	17.25 KLD
(b) Total Water Requirement for Fishing Boats			
For Vessel outfitting (fresh water)			
Outfitting trawlers in peak season 30 nos.	500 liter per boat		15 KLD
(c) Total Water Requirement for domestic demand			
For fishermen & port users within the FH complex Approx. 500 people	45 Liter per person		22.5 KLD
For Passenger jetty complex			2 KLD
Total Water KLD	**141.75**	**Approx**	**142 KLD**

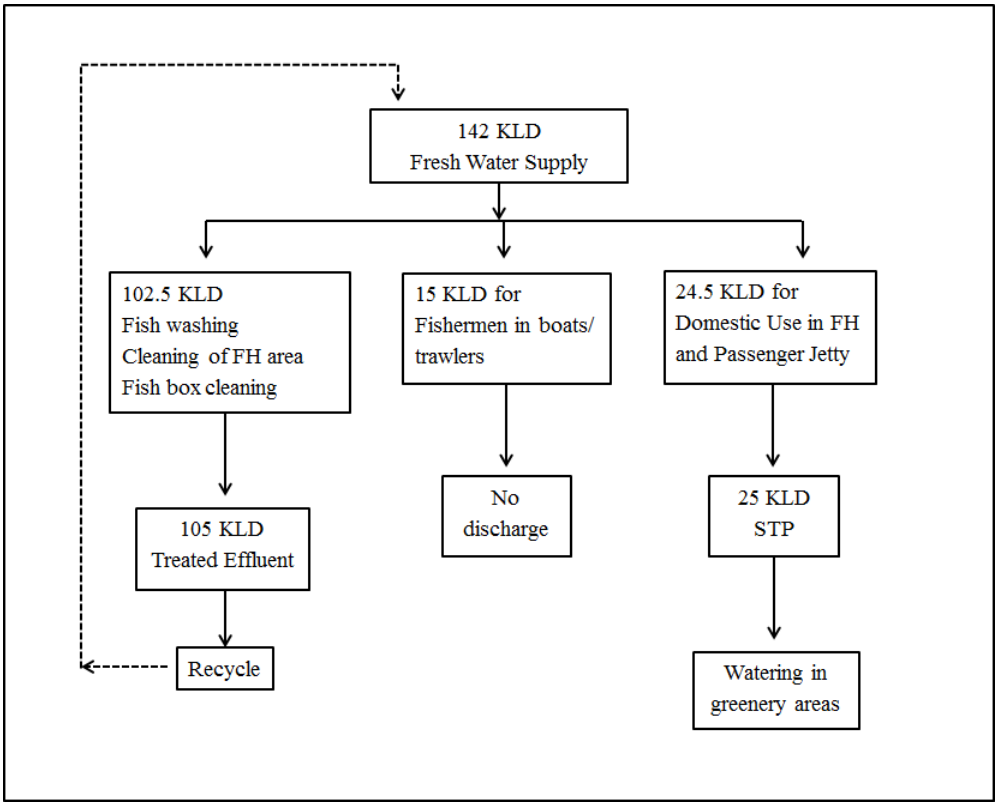


Figure 2.11: Water Balance of Fishing Harbour and Passenger Jetty

2.4.3. Construction Material

Stone, aggregate, sand/soil, gravel and cement will be procured from nearby licensed vendors as per requirement and availability. The requirement of the various construction materials are as follows

- Stone – 35,000 m^3
- Aggregate – 1,25,000 m^3
- Sand – 60,000 m^3

2.4.4. Timber

Timber requirement will be marginal for doors, windows and ventilators for theallied facilities of fishing jetty.

2.4.5. Energy (Electricity and Fuel)

The power for construction will be arranged from Goa Electricity Department. However, provisions shall also be made for diesel generator set to be used as back up during power outages.

2.5. Use of public infrastructure

A well-developed road infrastructure is already present within Mormugao Port. Transport of materials and personnel will be through the existing road. An approach road of 8.0m width and 50m length is proposed for connecting the project area to main city road.No new rail routes are proposed for this project.

2.6. Man power requirement

For the proposed development activities, manpower will be procured from nearby locality and on-site temporary camps for construction workers are not envisaged. The manpower requirement during the construction phase is about 70 persons per day.

2.7. Cost of the Project and Project Implementation Schedule

The details of the project cost are tabulated in Table 2.9 and project implementation schedule is given in Table 2.10.

Table 2.9: Cost of the proposed development activities at Mormugao Port

Sl. No	Proposed Development Activity	Cost (INR Crores)
1	Construction of Fishing Jetty	124.00
2	Development of Berth for Liquid bulk	190.17
3	Development of Coastal and Multipurpose Cargo Berth.	203.45
4	Development of Passenger Jetty, Launch and Port Craft Jetty	21.00
5	Deepening of Berths 10 & 11from -13.10 to -15.0m. (including the cost of strengthening)	130.00
6	Deepening of Breakwater Berth from -9.5 to -11.5m (including the cost of strengthening)	11.30
Grand Total		**679.62**

Table 2.10: Implementation schedule of Proposed development at Mormugao Port

Sl. No.	Proposed Development Activity	Implementation Schedule
1	Construction of Fishing Jetty	24 months
2	Development of Berth for Liquid bulk	24 months
3	Development of Coastal and Multipurpose Cargo Berth.	24 months
4	Development of Passenger Jetty, Launch and Port Craft Jetty	24 months
5	Deepening of Berths 10 & 11from -13.10 to -15.0m.	12 months
6	Deepening of Breakwater Berth from -9.5 to -11.5m	12 months

3. DESCRIPTION OF BASELINE ENVIRONMENT

3.1. General

The EIA determines the environmental consequences of the project prior to construction; assesses the impact on environment due to construction, on existing baseline environment; and also importantly on land use and socio-economic parameters; and suggests measures to eliminate or minimize negative impacts on the environment. Thus, the baseline study is an integral part of an EIA, as it helps to identify the environmental concerns already existing in that area. The entire baseline data has been collected through actual physical surveys and observations, literature surveys, interaction with locals, government agencies and departments.

This section of the EIA report describes the existing environmental settings in the study area. The purposes of describing the environmental setting of the study area are:

- To understand the project need and environmental characteristics of the area.
- To assess the existing environmental quality, as well as the environmental impacts due to the proposed development around the study area.
- To identify environmentally significant factors or geographical areas that could preclude any future development.

Environmental components to be considered in for the proposed modernization and expansion are (a) Land (b) Water-ground water, surface water (c) Marine (d) Air and meteorological (e) Noise (f) Biological (g) Socio-economic and occupational health (h) solid waste and (i) public utilities.

The establishment of baseline for different environmental components in the designated study area and at the project site has been conducted by field monitoring / investigation for baseline data generation. The data generation was carried out covering Ambient Air Quality, Noise Levels, Water Quality, Land Use, Soil Quality, Ecology, Hydrology and Socio-economic features. Besides, additional data/information regarding water availability, ecology, demographic pattern and socio-economic conditions were also collected from secondary sources.

3.2. Study area

The Study Area considered is within 10 km from periphery of project boundary. The Study Area Map is enclosed as Figure 3.1.

Figure 3.1: Study Area of 10 km Radius

3.3. Geology

The coastline of Goa extending from Tiracol in the north to Galgibagh river in the south consists of beaches, sea cliffs, promontories, estuaries, spits, dunes, weathering rocks and wave cut platforms, which provide good shelter for the boats, barges, ships and other crafts. In general, the coastline of district is uneven and consists of inlets and outlets which give rise to small bays and capes. The prominent landform is the laterite capped masses often extending 25 to 30 km inland. The average height of the cliffs varies from 40 to 100 m from the mean sea level. The laterite beds are reported in the estuaries of Chapora, Mondovi and Zuari at 20, 27 and 34 m respectively below the chart datum. The sea bed of Goa mostly consists of silty clay till 50 m to 100 m water depth, clayey silt from 100 to 150 m to 200 m water depth. Beach sediments mainly consist of quartz along with feldspars and other heavy minerals.

As per the Seismic Zone classification by IS 1893 (Part-I):2002, Goa forms part of the moderate seismic zone in the country, Zone III (Figure 3.2) of seismic zoning map of India, which indicates that Goa has moderate probability for occurrence of earthquakes.. Though Goa has not directly witnessed any earthquake it was affected by tremors from devastating earthquakes from neighbouring states, with magnitude 5.0 or more that hitted Koyna and Latur in Maharashtra in the year 1967 and 1993 respectively.

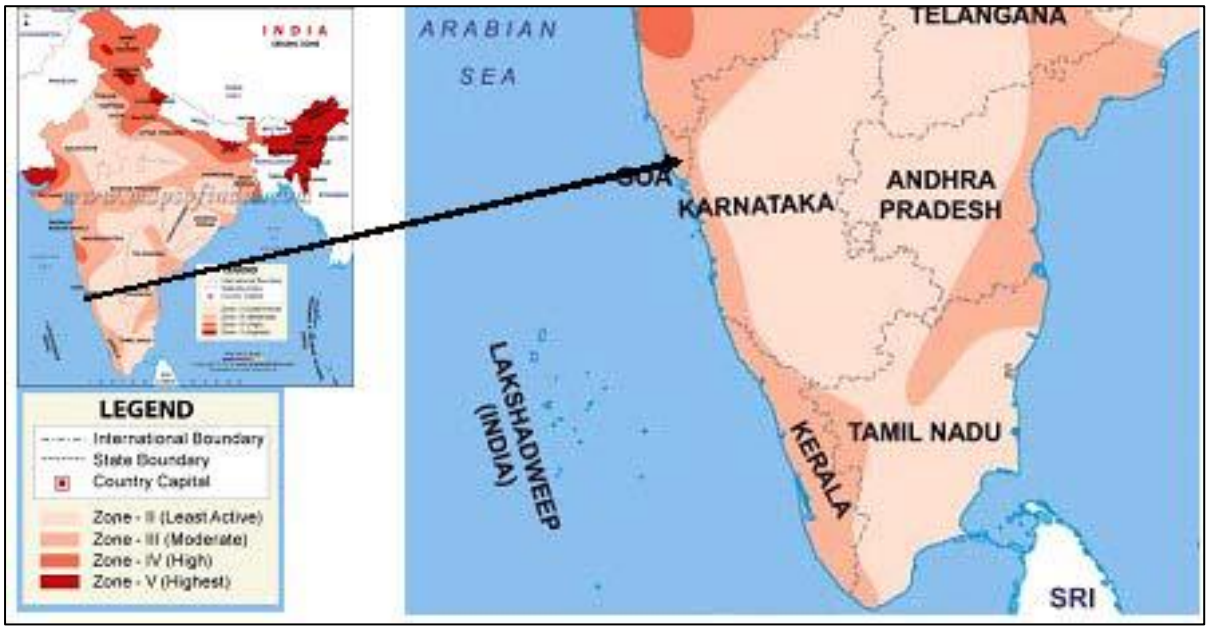


Figure 3.2: Seismic Zone of Study Area

The underlying geological formations of Goa consist of Pre-Cambrian rocks like quartz, Scricites, schist, metavolvnics, with layers of granite and basalt wedged into them. In fact, Goa forms part of the basaltic outflows of the lava of the Deccan plateau. On that account, it has land forms consisting of flat topped peaks with terraced flanks and opening valleys with thin sides raising more in the form of steps than as smooth slopes. The topography of the basaltic formations is attributed to weathering and water erosion, giving rise to residual Hill, characteristics of rounded summits and minor mounds

A small part of the area to its morth is covered by the Upper Cretaceous and Lower Eocene rocks of the Deccan trap which have a thin cap of porous laterite stone formation. These rocks have undergone a process of laterisation in varying degrees all over the state especially along the coastal area, where they occupy a depth of fifty to seventy-five (50-75 meters) from the surface. The process is attributed to the moist tropical climate of the region with its

seasonal change of rain sun and cold. Such laterite caps also codes extensively the upper Sahyadris and the medium and low level plateaus stretch below them, containing the mineral bearing pink phylliterocks.

There are also in this region consists of rocks of older formations, like metamorphic schists and shales of a lesser scale. These rocks consist of sub rounded cobbles, pebbles and boulders of a variety of quartzite's and gneissic granite cemented in a greywacke matrix. Embedded in these formations, at some places, are the dolerite dykes.

3.4. Soil

Soil is a vital natural resource, the proper use of which greatly determines the capability of life supporting system and the socio economic development of the people by providing food, fiber, fodder & fuel formatting the basic needs of human & animals. In EIA studies soil samples are primarily collected to understand status of agriculture soils and impacts of proposed development on soil. Proposed project is entirely located in marine zone and study area is mostly urbanized. Hence, very little patches of natural soils are available in study area. However, as per EIA guidelines surface Soil samples were collected from random 7 locations in the study area as shown in Table 3.1.

Table 3.1: Surface Soil Monitoring Locations Details

Sl. No.	Station Code	Location	Latitude	Longitude
1	S 1	MPT Colony	15°24'33.88" N	73°47'12.96" E
2	S 2	Vasco da Gama	15°23'45.50" N	73°48'15.87" E
3	S 3	Zuari Nagar	15°23'14.35" N	73°51'48.83" E
4	S 4	Cortalim	15°24'4.70" N	73°54'4.03" E
5	S 5	Bambolim	15°26'23.14" N	73°52'23.37" E
6	S 6	Dona Paula	15°27'33.84" N	73°48'34.83" E
7	S 7	Aguada	15°29'32.20" N	73°46'20.68" E

Figure 3.3: Map Showing Soil Monitoring Locations

Different Physicochemical Parameters like Colour, pH, Electrical Conductivity, Organic Matter etc. were analyzed during the monitoring. Summary of Surface Soil Monitoring results are given in Table 3.2. Laboratory monitoring results are attached as ***Annexure II***.

Table 3.2: Results of Surface Soil Monitoring

Sl. No.	Parameter	Unit	Surface Soil Sampling Locations						
			S1	S2	S3	S4	S5	S6	S7
1	Colour	-	Brown	Brown	Brown	Brown	Brown	Brown	Brown
2	pH	-	6.8	7.0	6.7	6.6	8.1	7.3	6.9
3	Electrical Conductivity	µS/cm	0.214	0.165	0.155	0.850	0.234	0.224	0.271
4	Organic Matter	%	3.4	2.2	0.9	1.1	1.2	1.5	3.7
5	Total Organic Carbon	%	1.9	1.3	0.5	0.6	0.7	0.9	2.1
6	Sodium as Na	mg/kg	38	22	23	33	13	17	20

Sl. No.	Parameter	Unit	Surface Soil Sampling Locations						
			S1	S2	S3	S4	S5	S6	S7
7	Potassium as K	mg/kg	12	14	7	40	43	26	39
8	Phosphate as PO4	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL
9	Nitrate as NO3	mg/kg	BDL	BDL	BDL	11	BDL	BDL	13
10	Cadmium as Cd	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11	Chromium as Cr	mg/kg	299	189	405	338	162	239	212
12	Cobalt as Co	mg/kg	6	BDL	BDL	BDL	BDL	14	BDL
13	Copper as Cu	mg/kg	48	43	28	28	26	71	54
14	Iron as Fe	mg/kg	37514	39788	64472	68056	12227	21462	31465
15	Lead as Pb	mg/kg	5	2	BDL	BDL	6	BDL	17
16	Manganese as Mn	mg/kg	1356	403	203	651	720	1244	1102
17	Nickel as Ni	mg/kg	41	7	BDL	BDL	14	31	21
18	Zinc as Zn	mg/kg	118	84	33	53	49	67	191

3.5. Land Use/Land Cover

Land Use/Land Cover data refers to data that is a result of classifying raw satellite data into "land use and land cover" (LULC) categories based on the return value of the satellite image. Land cover is a fundamental parameter describing the Earth’s surface whereas land use documents how people are using the land.

3.5.1. Satellite Image Analysis

The study area is considered to be area within a radius of 10 km of the Project site at Mormugao port. Landsat 8 cloud free data has been used for Landuse / landcover analysis and Cartosat-1data for analysing topographic features, the details of satellite image are as follows:

Landsat 8

- **x** Satellite Sensor – OLI_TIRS
- x Path and Row – Path 147, Row 49
- x Spatial Resolution– 30 m
- x Date of Pass: 24th February 2017

Cartosat-1:-

- **x** Satellite Sensor – PAN (2.5M) Stereo data
- x Spatial Resolution– 1 arc sec
- x Theme - Terrain
- x Date of Pass: 29th April 2015

Ancillary Data: GIS and image-processing software are used to classify the image and for delineating drainage and other features in the study area. Figure 3.4 shows the colour composite satellite map of 10 km radius area from the proposed project site. Band combination was done from the collected satellite data to create the satellite map of the study area.

3.5.2. Land Use Land Cover Details

Satellite data was classified using supervised classification technique. Maximum likelihood algorithm classifier was used for the analysis. Eight land use/ land cover classes were identified in ten sq. km area around the Project site (Figure 3.5). Table 3.3 shows the information about the extent of landuse / landcover classes in the study area.

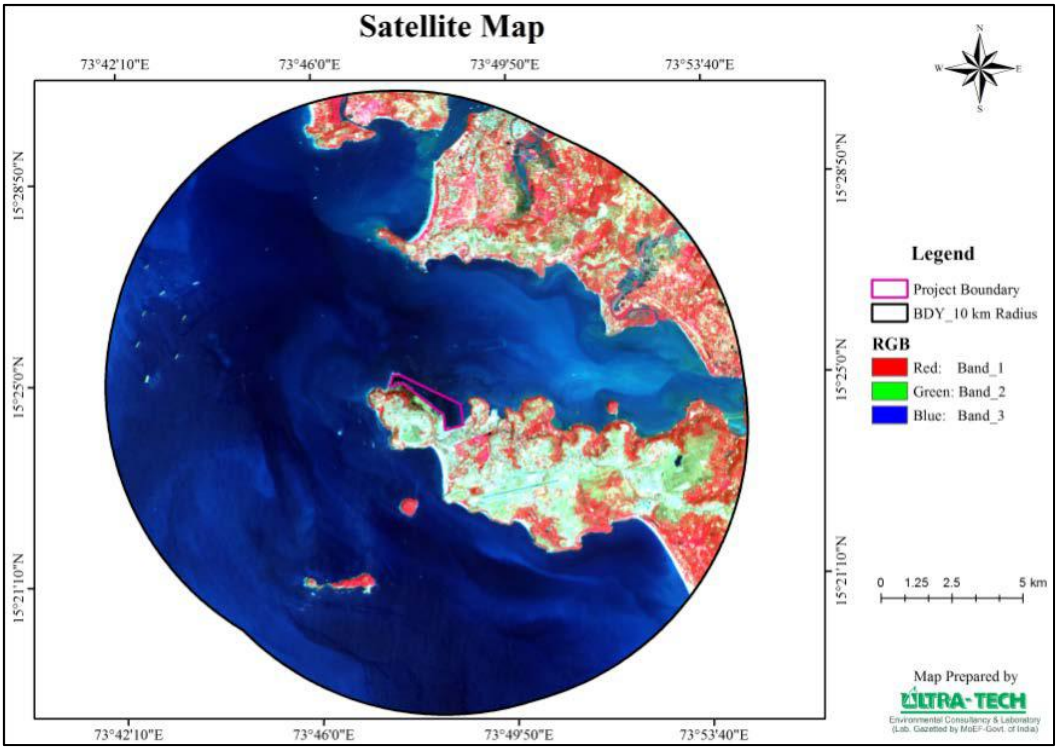


Figure 3.4: Satellite Map of Study Area

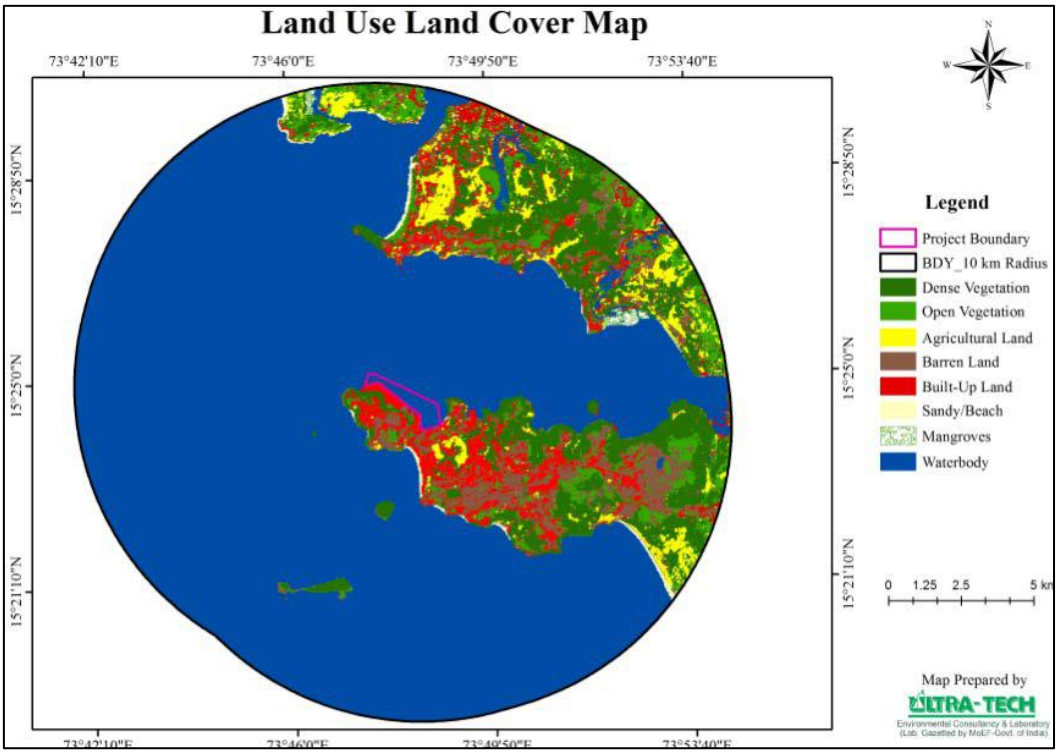


Figure 3.5: LULC Map of Study Area

Table 3.3: Landuse / Landcover Statistics of Area within 10 km Radius

LULC Classes	Area(Ha)	Percentage of total area (%)
Dense Vegetation	3415.71	8.87
Open Vegetation	2056.66	5.34
Barren Land	1943.69	5.05
Agricultural Land	1169.69	3.04
Built-up Land	1631.18	4.24
Mangroves	75.78	0.2
Sandy/Beach	246.17	0.64
Waterbody	27977.1	72.64
Total	**38516**	**100**

Water body (73.36%) dominates in the present land use pattern covering 10 km surrounding of the proposed development area. 8.89% of lands have dense vegetation, while 4.33% have open vegetation. Barren lands were occupied 5.76% of the total land use. Built-up land use occupies in 4.36% and 2.66% areas were agricultural lands. Remaining land use were Sandy/Beaches (0.48%) and mangroves (0.16%). Due to the proposed development there were no variations in the existing land use pattern within the study area. But within in proposed development area there may be some minor change in land use to Built-up.

Contour Pattern of the Study Area

Contouring is the standard method of representing relief on topographic maps. Contour lines are lines joining points of equal elevation on the surface of the ground. For a given map the vertical distance between adjacent contour lines or the contour interval is fixed i.e.20 m Figure 3.6. Contour map of 10 km radius around project site predominantly shows an undulating terrain.

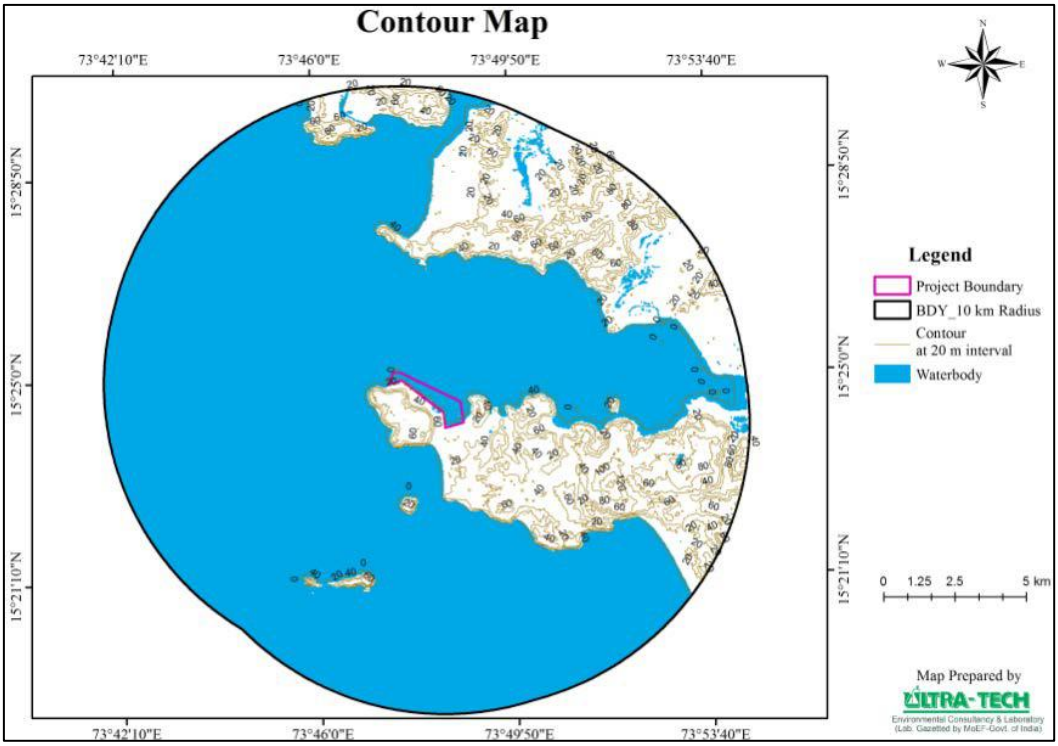


Figure 3.6: Contour Pattern of 10 km Study Area

Drainage Map of the Study Area

A drainage system is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. Drainage basin can be described by the order of streams within them. Streams that have no tributaries (or streams flowing into it) are termed first order streams. When the first order streams join together, they become second order steam. Two second order streams join to form third order stream and so on for forth and further orders. However, a stream may have a tributary with a lower order without becoming a higher order stream. Strahler method of ordering was used for giving order to drainage.

Drainage map Figure 3.7 of a study area shows highest order of drainage as 4th order i.e. Zuari river. Drainage pattern within 10 km radius around project site shows both parallel and dendritic type of drainage pattern.

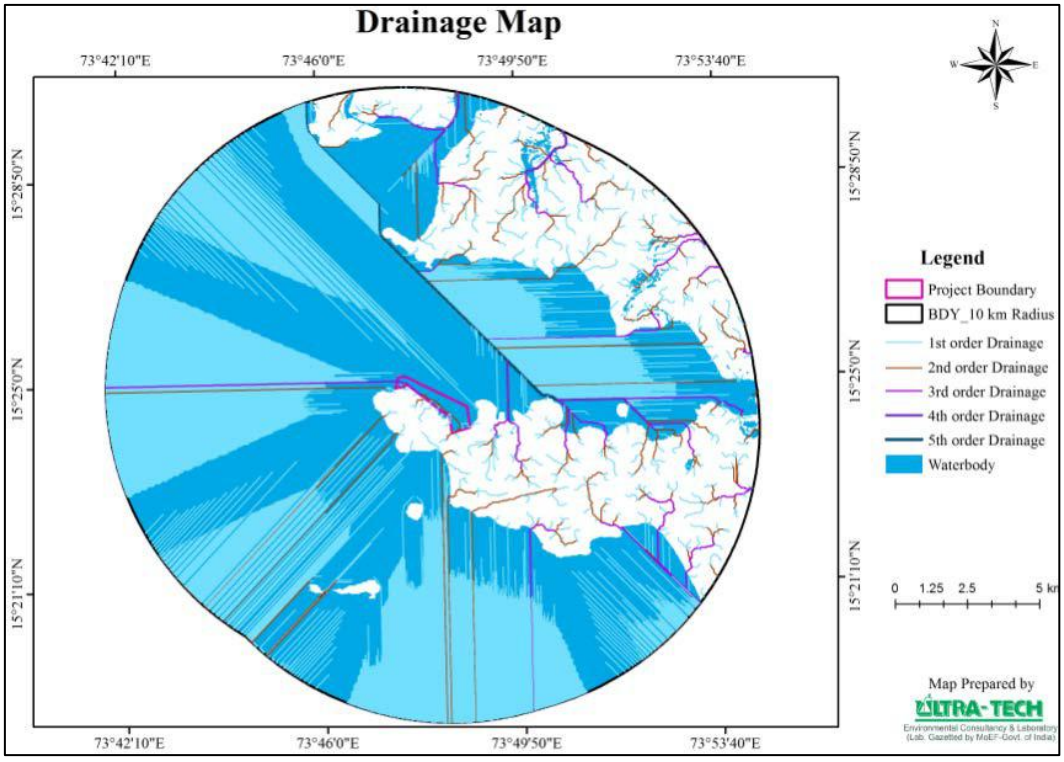


Figure 3.7: Drainage Pattern of 10 km Study Area

3.6. Water Environment

The study area is covered under Zuari River system and Arabian Sea. The entire Goa State is drained by a network of nine estuarine rivers, namely Terekhol, Chapora, Baga, Mandovi, Zuari, Sal, Saleri, Talpona and Galgibag River. Most of the rivers originate in the Western Ghats and discharge into the Arabian Sea. They are characterised by imperceptible gradients in the lower reaches resulting in the tidal waters entering several kilometres inland. It's the largest river in the state covering 92 kms. The river is connected to Mandovi River through Cumbarjua canal. Salaulim dam is a major irrigation project located on Zuari River.

The Zuari and Mandovi Rivers form an estuarine system. They are the backbone of Goa's agricultural industry. The estuary has dense mangrove vegetation filled with silt, clay and detritus that has been transported by riverine influx from upper reaches. The entire mudflats along with mangrove vegetation make the region highly productive supporting large number of economically important species. This region receives the maximum precipitation during the southwest monsoon accompanied by stormy weather, while quieter conditions prevail during rest of the year.

Water Quality Monitoring

The propose project is entirely located in marine zone and nearest fresh water pond i.e. Vaddem Lake is 1.8 km from project site. Any impact due to proposed project on fresh water bodies as well as groundwater aquifer is remotely possible. However, the status of nearest fresh water bodies and groundwater in the study area was monitored as per EIA guidelines. Ground water samples were collected from 2 locations in the study area. Samples were collected from bore well. In order to study the existing fresh water quality within the study area, samples were collected from 3 different stations. Sampling Locations are listed in Table 3.4.

Table 3.4: Water Monitoring Locations Details

Sl. No.	Station Code	Location	Latitude	Longitude
1	GW 1	Vasco da Gama	15°23'45.50" N	73°48'15.87" E
2	GW 2	Goa Velha	15°26'23.14" N	73°52'23.37" E
3	SW 1	Maimollem Lake	15°23'59.56" N	73°49'40.19" E
4	SW 2	Vaddem Lake	15°23'52.83" N	73°49'16.64" E
5	SW 3	Baina Lake	15°23'12.15" N	73°48'49.75" E

Different Physio-chemical Parameters like Temperature, Turbidity, pH, Electrical Conductivity, Total Dissolved Solids, Total Hardness etc. were analysed during the monitoring. Summary of Water Monitoring is given in Table 3.5. Laboratory monitoring results are attached as ***Annexure III***.

From analysis of surface and groundwater samples it was observed that water samples are not suitable for drinking as per IS 10500:2012 standards. Total dissolved solids of GW2 and SW2 exceeded beyond permissible levels of 500 mg/l. Similarly Total Hardness at GW2, SW2 and SW3 exceeded permissible levels of 200 mg/l. Chloride values were observed between 13 to 4238 mg/l and exceeded beyond permissible levels of 250 mg/l at GW2 and SW2. Coliform bacteria were observed at almost all locations.

Table 3.5: Surface and Groundwater Quality of Study Area

Sr. No.	Parameters	Unit	GW 1	GW 2	SW 1	SW 2	SW 3	IS 10500
1.	Colour	Hazen	BDL	BDL	BDL	BDL	BDL	5
2.	Odour	-	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
3.	Temperature	0C	26.7	27.3	27.3	27.2	27.0	-
4.	Turbidity	NTU	1.1	BDL	10.3	1.4	6.1	1
5.	pH	-	7.1	7.3	6.7	7.3	6.8	6.5 – 8.5
6.	Electrical Conductivity	µS/cm	113	1465	514	12110	649	-
7.	Total Dissolved Solids	mg/L	76	952	334	7870	422	500
8.	Total Hardness as CaCO3	mg/L	44	339	105	1414	214	200
9.	Calcium Hardness as CaCO3	mg/L	24	182	BDL	BDL	BDL	200
10.	Ammoniacal Nitrogen as NH3-N	mg/L	BDL	BDL	BDL	BDL	BDL	0.5
11.	Nitrates as NO3-N	mg/L	0.23	1.73	BDL	BDL	BDL	45
12.	Phosphates as PO43-	mg/L	BDL	0.19	0.21	0.06	0.42	-
13.	BOD (270C, 3Days)	mg/L	BDL	BDL	BDL	BDL	BDL	-
14.	COD	mg/L	8	16	12	8	20	-
15.	Dissolved Oxygen	mg/L	6	5.7	5.8	5.9	5.7	-
16.	Potassium as K	mg/L	1.3	4.2	5.2	81	3.8	-

17.	Sodium as Na	mg/L	8.1	224	68.3	2543	54.3	-
18.	Calcium as Ca	mg/L	10	73	31	81	62	75
19.	Magnesium as Mg	mg/L	5	38	7	295	15	30
20.	Carbonates (CO3-2) as CaCO3	mg/L	BDL	BDL	BDL	BDL	BDL	200
21.	Bicarbonates as CaCO3	mg/L	41	90	104	146	200	-
22.	Chlorides as Cl-	mg/L	13	380	97	4238	85	250
23.	Sulphates as SO42-	mg/L	12	168	37	495	48	-
24.	Fluoride as F-	mg/L	0.24	0.43	0.38	0.52	0.49	1
25.	Boron as B	mg/L	0.1	0.4	0.4	0.7	0.5	0.5
26.	Iron as Fe	mg/L	BDL	BDL	BDL	BDL	BDL	0.3
27.	Zinc as Zn	mg/L	BDL	BDL	BDL	BDL	BDL	5
28.	Total Coliform Bacteria	MPN/100 ml	BDL	13	>1600	900	>1600	Absent
29.	Faecal coliform	MPN/100 ml	BDL	BDL	26	50	170	Absent
30.	E. Coli	-	Absent	Absent	Present	Present	Present	Absent

3.7. Marine Environment

3.7.1. Marine Water

Marine water monitoring was conducted in April 2017 to establish the existing status of seawater around the proposed project site. The study covered sample collection and analysis of physicochemical and biological characteristics of seawater samples. Marine water was collected from eight representative locations. Details of sampling locations are given below in Table 3.6.

Table 3.6: Details of Marine Sampling Locations

Station Code	Latitude	Longitude
MW1	15°25'15.77" N	73°46'30.68" E
MW2	15°25'2.32" N	73°47'9.89" E
MW3	15°25'0.93" N	73°47'38.69" E
MW4	15°24'44.34" N	73°48'8.19" E
MW5	15°24'20.13" N	73°48'32.24" E
MW6	15°24'27.13" N	73°48'52.47" E
MW7	15°24'46.33" N	73°49'4.14" E
MW8	15°25'9.70" N	73°48'32.36" E

Figure 3.8: Map showing Marine Sampling Locations

Physicochemical characteristics of surface seawater and bottom seawater are given in Table 3.7 and Table 3.8, respectively.

There was no significant difference in the water temperature which ranged between 26.9°C to 27.6°C in entire area. pH values were stable and did not show much variations. pH ranged between 7.6 to 7.9. The salinity of the water varied from 33.4 ppt to 37.0 ppt. The dissolved oxygen, the most important parameter that influences the health and diversity of biota, varied in 5.0 to 6.2 mg/L range indicating well mixing of water. In natural marine waters free from organic pollution the dissolved oxygen is generally close to 100% saturation. Depressed values at the project site indicate influence of oxidizable organic matter such as sewage entering the system. However, the low BOD (BDL [DL=2]) suggests that the anthropogenic organic matter entering the waters is effectively oxidized.

Under the Environment Protection Rules, 1986, water quality criteria have been specified for five designated best uses. Under this classification harbour waters are classified as Class SW-IV. The results presented in Table 3.7 indicate that the study area meets the criteria of Class SW-IV. Laboratory monitoring results are attached as ***Annexure IV***.

Primary Water Quality Criteria for Class SW-IV Waters (For Harbour Waters)

S.No.	Parameter	Standards
1	pH range	6.5-9.0
2	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value, which ever is higher.
3	Colour and Odour	No noticeable colour or offensive odour.
4	Floating Matters Oil, grease and scum (including Petroleum products)	10 mg/l
5	Fecal Coliform	500/100 ml (PAN)
6	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/l

Table 3.7: Results of Marine Surface Water Sampling

Sr. No.	Parameter	Unit	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
1	pH	-	7.9	7.7	7.8	7.9	7.9	7.7	7.8	7.9
2	Temperature	0C	26.9	27.2	27.3	27.1	27.3	27.3	26.9	27.5
3	Electrical Conductivity	µS/cm	54100	54400	55200	55500	53900	54100	55600	56400
4	Chlorides as Cl-	mg/L	19764	19975	20678	20959	19553	19904	20186	20467
5	Salinity	ppt	35.7	36.1	37.4	37.9	35.3	36.0	36.5	37.0
6	Total Dissolved Solids	mg/L	35140	35320	35820	36080	34890	35310	36120	36650
7	Total Suspended Solids	mg/L	202	194	42	21	28	18	25	24
8	Ammonical Nitrogen	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
9	Nitrates as NO_3-^{N}	mg/L	0.18	0.20	0.19	0.15	0.13	0.24	0.11	0.23
10	Nitrite as NO_2-^{N}	mg/L	0.005	0.004	0.010	0.009	0.008	0.006	0.007	0.016
11	Phosphates as PO_4^{3-}	mg/L	0.06	0.15	0.06	0.28	0.15	0.26	0.21	0.18
12	Sulphates as SO_4^{2-}	mg/L	3021	3024	3187	3198	3084	3245	3190	3290
13	BOD (27^0C, 3Days)	mg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
14	COD	mg/L	12	20	24	28	24	12	28	32
15	Dissolved Oxygen	mg/L	5.1	5.6	5.9	5.5	5.3	5.7	5.3	5.0
16	Potassium as K	mg/L	178	188	192	197	190	204	194	210
17	Sodium as Na	mg/L	11140	11200	11400	11500	11800	11800	11900	11980
18	Phenol	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Oil & Grease	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Table 3.8: Results of Marine Bottom Water Sampling

Sr. No.	Parameter	Unit	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
1	pH	-	7.8	7.6	7.8	7.8	7.8	7.6	7.8	7.8
2	Temperature	0C	27.1	27.1	27.5	27.2	27.2	27.5	27.1	27.6
3	Electrical Conductivity	µS/cm	51200	51700	51400	51700	53300	53800	52500	56400
4	Chlorides as Cl-	mg/L	18498	18779	18568	18990	18498	18849	18920	20467
5	Salinity	ppt	33.4	33.9	33.5	34.3	33.4	34.1	34.2	37.0
6	Total Dissolved Solids	mg/L	33240	33580	33390	33570	33280	33610	34120	36650
7	Total Suspended Solids	mg/L	184	210	45	25	33	22	27	24
8	Ammonical Nitrogen	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
9	Nitrates as NO3-N	mg/L	0.22	0.24	0.25	0.23	0.24	0.32	0.18	0.23
10	Nitrite as NO2-N	mg/L	0.006	0.007	0.008	0.006	0.010	0.017	0.012	0.016
11	Phosphates as PO43-	mg/L	0.18	0.21	0.24	0.34	0.29	0.33	0.35	0.38
12	Sulphates as SO42-	mg/L	3147	3254	3210	3204	3168	3287	3256	3387
13	BOD (270C, 3Days)	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14	COD	mg/L	8	12	8	12	16	8	12	12
15	Dissolved Oxygen	mg/L	5.3	5.8	6.2	5.8	5.6	6.0	5.9	5.5
16	Potassium as K	mg/L	147	158	164	172	157	188	178	188
17	Sodium as Na	mg/L	10500	10400	10600	10700	11000	11200	11300	11200
18	Phenol	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Oil & Grease	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

3.7.2. Tides

The nature of tide prevailing at Mormugao is mainly semi-diurnal exhibiting two high and two low waters in a tidal day. The mean tidal variation is of the order of 1.6m at spring tide and around 0.7m at neap tides. Based on Indian Naval Hydrographic Chart No. 2020, the tide levels with respect to chart datum at Mormugao Harbour are given in Table 3.9.

Table 3.9: Tide levels with respect to Chart Datum

Higher High water at Spring	+2.3 m
Mean Higher High Water (MHHW)	+1.9 m
Mean Lower High Water (MLHW)	+1.8 m
Mean Higher Low Water (MHLW)	+1 m
Mean Lower Low Water (MLLW)	+0.5 m
Mean Sea Level (MSL)	+1.3 m

3.7.3. Waves

Mormugao is subjected to dominant wave action from northwest and west directions during non-monsoon and monsoon seasons respectively. The port is, however protected naturally by Mormugao headland from south westerly waves occurring during southwest monsoon season. The deep water waves from northwest generally have a small probability exceeding and do not affect harbour tranquillity significantly since their heights get reduced by the time they reach the harbour. Wave periods during the monsoons tend to be longer than during the rest of the year when NW winds prevail. The currents are of the order of 0.12 m/s in the harbour area.

3.7.4. Bathymetry

Bathymetry is one most important input for the mode. Bathymetry was obtained from available hydrographic charts as supplied by the MPT and from MIKE-21 C map data. The depths in proposed development are varying between -4 to -6 m. Towards sea side, it covers soundings up to (-) 56 m depth contours below CD.

Bathymetry details indicate that the seabed over a major portion of the surveyed area is generally smooth. Natural water depth (not including the dredged channel) increases gently from 4m along the eastern boundary to 8m near the harbor entrance, 3.5 km to the west.

In the western part, however, the water depths are extremely irregular, with depths increasing to more than 11m, while rocks outcrops are found within the northern boundary. The depths within Vasco Bay between the eastern headland and the existing cargo Berth11 are generally less than 3.5 m below chart datum (mean low water).

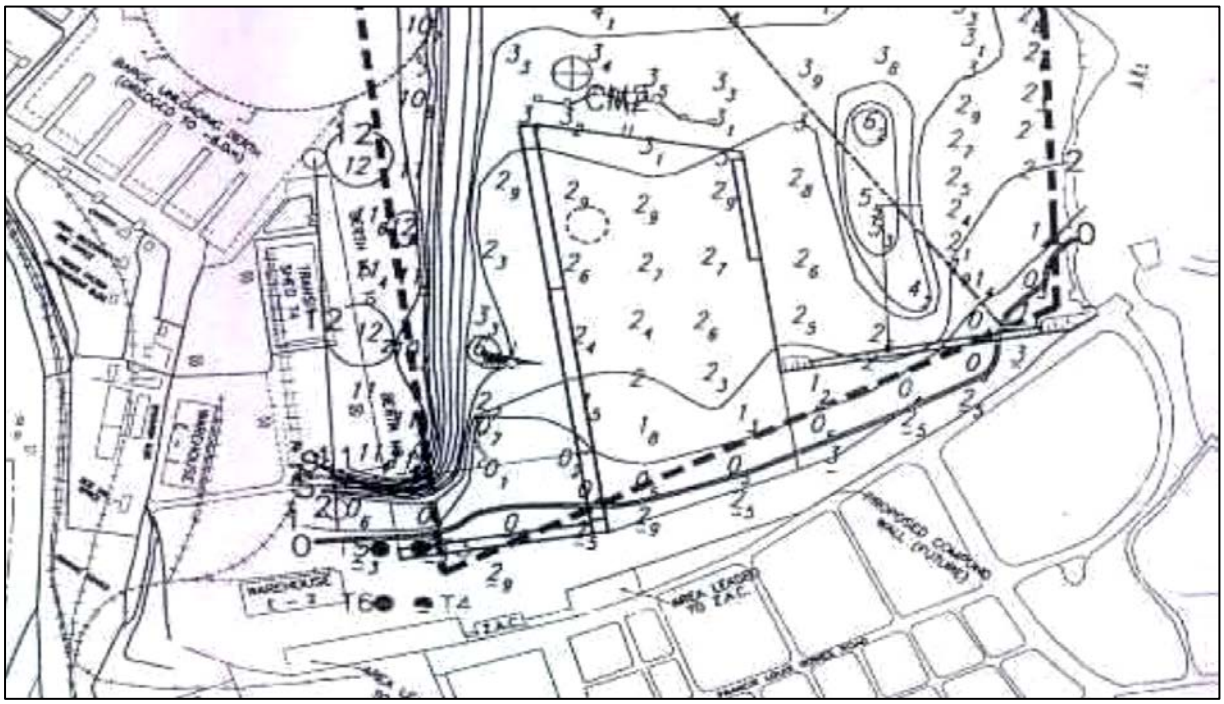


Figure 3.9: Bathymetry Chart of Vasco Bay

3.7.5. Sediments

A close relationship exists between the sediments and physicochemical and biological parameters of water. Similarly, the activities in the area also have a profound effect on the sediment composition. Hence, an understanding of the physicochemical and biological characteristics of the sediments is essential. With this view, the sediment samples from selected marine sampling stations were collected. Details of the sampling locations are given in the Table 3.10. The sediment sampling locations are shown in Figure 3.11.

Table 3.10: Sediment Sampling Location details

Sl. No.	Station Code	Type	Latitude	Longitude
1	SD 1	Subtidal	15°25'15.77" N	73°46'30.68" E
2	SD 2	Subtidal	15°25'2.32" N	73°47'9.89" E
3	SD 3	Subtidal	15°25'00.93" N	73°47'38.69" E
4	SD 4	Subtidal	15°24'44.34" N	73°48'8.19" E
5	SD 5	Subtidal	15°24'20.13" N	73°48'32.24" E
6	SD 6	Subtidal	15°24'27.13" N	73°52.47" E
7	SD 7	Subtidal	15°24'46.33" N	73°48'4.14" E
8	SD 8	Subtidal	15°24'9.70" N	73°48'32.36" E
9	IT - I	Intertidal	15°24'9.11" N	73°48'53.48" E
10	IT - II	Intertidal	15°24'18.13" N	73°47'12.46" E

Figure 3.10: Map showing Sediment Sampling Locations

Results for the same are described in Table 4.13. Laboratory monitoring results are attached as ***Annexure V***. Total Organic carbons in study area were between 0.7-2.8 % in subtidal

sediment samples and 0.2-0.5 % in intertidal sediment samples. Organic Nitrogen concentrations were ranges between 338-1092 mg/kg in subtidal sediments samples and 23-97 mg/kg in intertidal sediment samples respectively. Total Phosphorus concentrations were 1437-8577 mg/kg in subtidal sediment samples and 215-248 mg/kg in intertidal sediment samples respectively while Iron concentrations were 8954-13029 mg/kg in subtidal sediment samples and 1135-9694 mg/kg in intertidal sediment samples at the respective stations. Manganese concentrations were 50-706 mg/kg in subtidal sediments and 14-20 mg/kg in intertidal sediment samples respectively. Zinc concentrations were 31-69 mg/kg in subtidal sediments and 9-10 mg/kg in intertidal sediment samples respectively. High concentrations of heavy metals in sediment are attributed to extensive maritime and marine industrial activities in Mormugao Harbour region. Disturbance to sediment due to dredging will lead to further deterioration of water column due to suspension of polluted sediment.

Table 3.11: Results of Sediment Sample Monitoring

Sr. No.	Parameter	Unit	Subtidal Sediments								Intertidal Sediments	
			SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8	IT-I	IT-II
1	Color	-	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Off White	Off White
2	pH(1:2:5 Soil: Water)	-	7.7	8.1	7.7	7.6	7.9	8.0	7.7	8.1	8.2	8.3
3	Organic Matter	%	4.8	1.2	4.6	3.8	3.7	3.6	3.0	2.8	0.4	0.9
4	Total Organic Carbon	%	2.8	0.7	2.7	2.2	2.2	2.1	1.8	1.6	0.2	0.5
5	Oil & Grease	%	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5	0.3
6	Organic Nitrogen	mg/kg	338	919	1092	766	624	571	548	521	23	97
7	Total Phosphorus as P	mg/kg	8577	2879	7568	5286	4101	3351	2142	1437	248	215
8	Sulphide	mg/kg	6.4	7.9	12.3	15.4	14	11	8	5	36	33
9	Cadmium as Cd	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10	Chromium as Cr	mg/kg	78	69	65	54	62	42	40	38	22	18
11	Copper as Cu	mg/kg	51	15	23	13	10	9	9	9	BDL	BDL
12	Iron as Fe	mg/kg	12567	11192	13029	12234	10587	9854	9435	8954	9694	1135
13	Lead as Pb	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14	Manganese as Mn	mg/kg	617	440	706	63	61	59	54	50	14	20
15	Nickel as Ni	mg/kg	6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16	Zinc as Zn	mg/kg	69	47	50	43	41	39	35	31	9	10

3.8. Meteorology

Goa experiences a tropical monsoon climate under the Koppen climate classification. Goa, being in the tropical zone and near the Arabian Sea, has a hot and humid climate for most of the year. The calendar year in the project area can be divided into four main seasons. The winter season lasts from December to February followed by pre-monsoon season from March to May. The monsoon season begins in June and continues up to mid-October. The period from mid-October to November constitutes the post-monsoon season. The average meteorological conditions of the Mormugao as per observation of IMD from 1981-2010 are summarized given in Table 3.12.

Table 3.12: Meteorological Data of Mormugao (IMD 1981-2010)

Month	Temperature (oC)		Rainfall (mm)	Relative Humidity (%)		Mean Wind Speed (kmph)
	Maximum	Minimum		08.30 hrs	17.30 hrs	
January	31.8	21.9	0.4	72	64	7.1
February	31.3	22.3	0	75	67	8.4
March	31.9	24.2	0.2	78	71	9
April	32.8	26.2	3.7	76	71	9.4
May	33.2	27.1	90.6	76	73	9.9
June	30.7	25.2	831.5	87	84	13.4
July	29.2	24.5	824.5	89	86	14.9
August	28.9	24.2	550.2	90	87	11.7
September	29.9	24.3	256.3	88	83	7.4
October	31.6	24.6	136	82	78	6
November	33.1	23.8	19.7	70	67	5.4
December	32.7	22.5	5	67	63	5.9
Total			2718			
Average	31.4	24.2		79	74	9.0

Source: IMD, Goa

3.8.1. Temperature

Marginal variations in the daily maximum temperatures are observed throughout the year, as they range from 28.90C to 33.20C. The minimum temperatures, however show greater variations, range from 21.90C to 27.10C. The temperature rises rapidly after September and the month of November is the hottest month of the year with mean daily maximum

temperature rising up to 33.20C. Goa has a short winter season between mid – December and February. The months of January and February are the coldest months of the year, and mean daily minimum temperature goes to 21.90C. The month wise Temperature variations in the project area is shown in Figure 3.12.

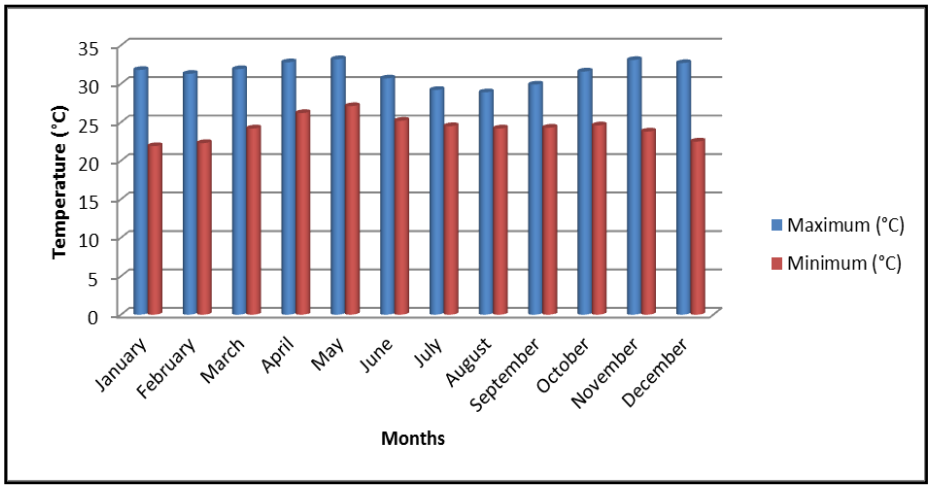


Figure 3.11: Temperature variation in Project Area

3.8.2. Rainfall

The annual rainfall in the project area is about 2718 mm and the annual mean number of rainy days is about 94. Majority of the rainfall is received in the months from June to September due to the influence of South - West monsoon. Usually maximum average monthly rainfall of 831.5 mm occurs in June followed by 824 in the month of July. February is generally the driest month of the year. There is practically no rainfall from December to April. The month wise Rainfall received in Mormagao is depicted in Figure 3.13.

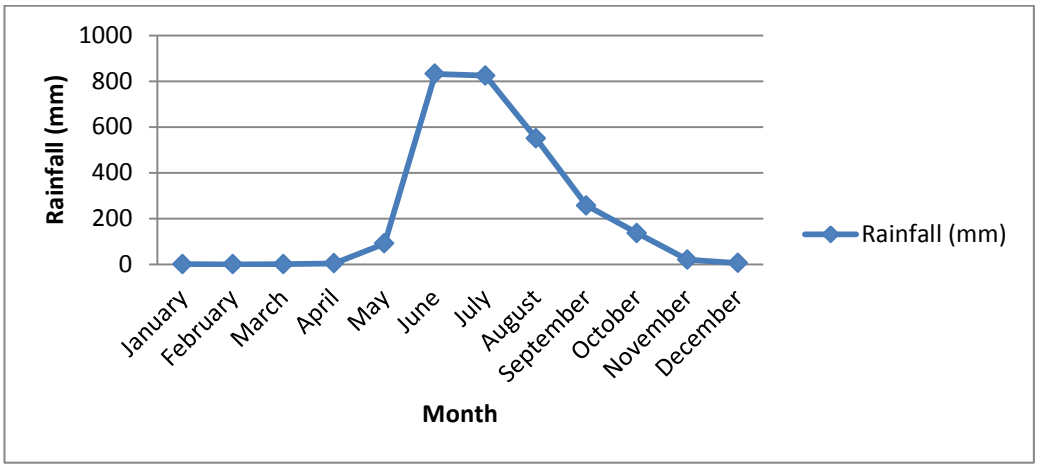


Figure 3.12: Rainfall variations in the Project Area

3.8.3. Relative Humidity

The relative humidity was observed to be high during the monsoon months from June to October. The relative humidity was lower in other months of the year, with the lowest being recorded in the months of November and December. The mean yearly relative humidity at 08.30 hours is 79% and 74% at 17.30 hours. The monthly average humidity is lowest in December (63%) and highest in August (90%). The month wise variations in Relative Humidity is given in Figure 3.14.

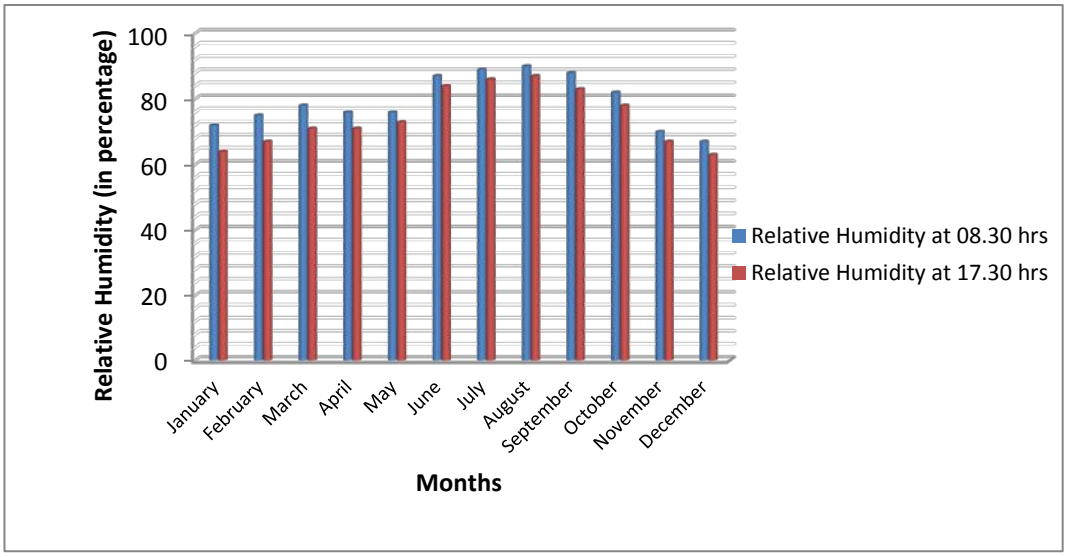


Figure 3.13: Monthly variations in Relative Humidity

3.8.4. Winds

The mean sea wind varies from 2 on the Beaufort scale in November to 4 in July. The annual mean sea wind speed is of the order of 13.6 kmph. In an average year, there are 316 days with wind speed varying between 0 to 3 on the Beaufort scale and 48 days with winds varying between 4 to 7 on the Beaufort scale.

The predominant wind direction changes with the time of the year. During the period from June – September, wind blows from the west and south- west. During the remaining period, the wind direction is from NE, ESE during the evening. The highest speed of 105 km/hr was recorded in June 1994. Winds of force more than 10 on the Beaufort scale are not expected.

Considerable changes in the wind direction occur in coastal areas as a result of cooling in night and warming of land masses during day time. The frequency of depressions/cyclonic storms is very low along the Goa coast. Out of the 206 depressions/cyclonic storms severe

cyclonic storms which have occurred in the Arabian Sea during a period of 103 years (1891-1994) only six have affected the Goa coast. The month wise Mean Wind Speed is given in Figure 3.15.

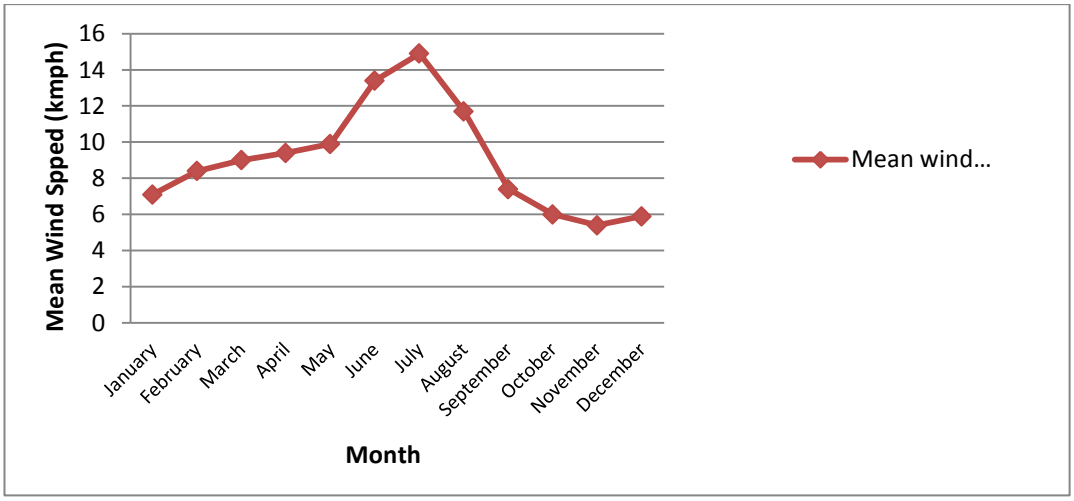


Figure 3.14: Mean Wind Speed variations in Project Area

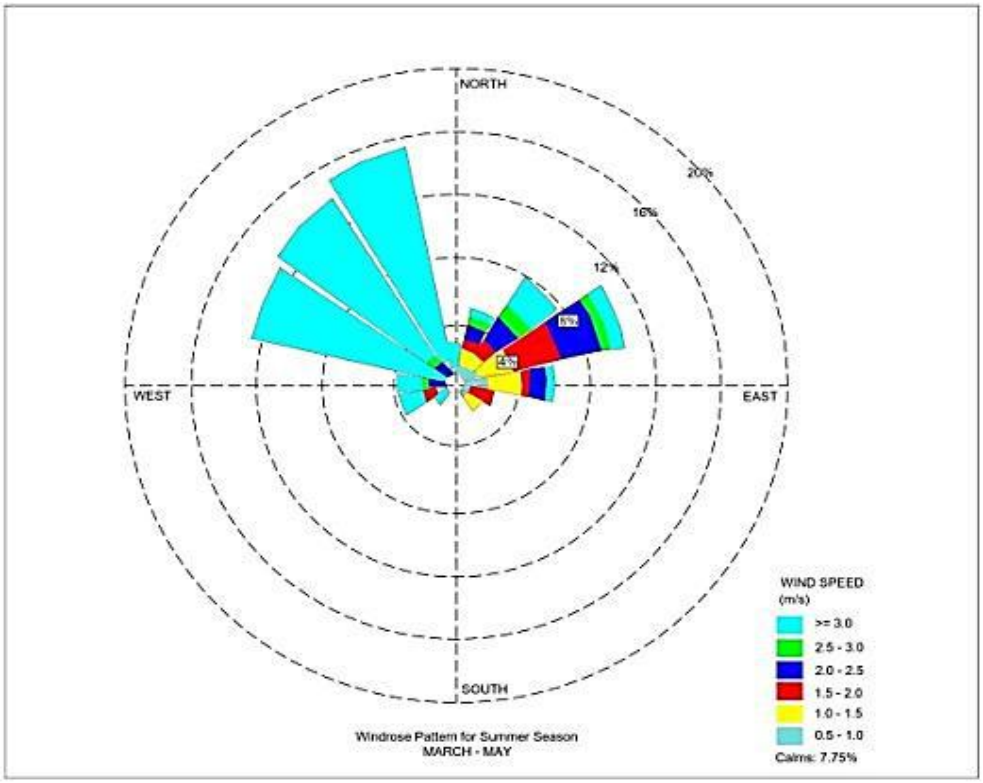


Figure 3.15: Windrose diagram

3.8.5. Visibility

Sometimes mist develops during sunrise on the west coast, above latitude 16° N, but disperses thereafter. Smog hangs over the land at Goa from November to March obscuring everything in view mostly after sunrise and occasionally in the evenings. However, the smog lasts only for short durations. Visibility is generally good for most part of the year.

3.8.6. Cyclone

In general the west coast of India is less prone to cyclonic storms compared to the east coast. The frequency of depression/cyclonic storm is very low along the Goa coast. From the information reported by India Meteorological Department (IMD), a total of 1034 disturbances occurred in the Bay of Bengal during the period from 1891 to 1970, of which 363 intensified to cyclonic storms, the rest being ‘depressions’. On an average the number of cyclonic disturbances per year during this period was about 13. However, if the data is updated to 1990, the number of cyclonic events per annum works out to be 16, varying from a minimum of 8 to a maximum of 18.

The above cyclones may be divided into two broad categories. The first group consists of cyclones that originate in the Bay of Bengal and cross the east coast at certain locations. These storms pass over the Indian landmass and lose their strength before crossing the west coast. The second group consists of cyclones that cross over to the Arabian Sea at the southern tip of the Indian Peninsula and veer northwards towards Saurashtra. These cyclones are much stronger and more dangerous for the west coast and normally occur during the transition months of May and November. Tracks of the cyclones in the Arabian Sea from 1877 to 1992 are presented in Figure 3.17. It may be seen there from that only 10 storms endangering the Mumbai coast have occurred in the above said period that is at a frequency of once in 12 years.

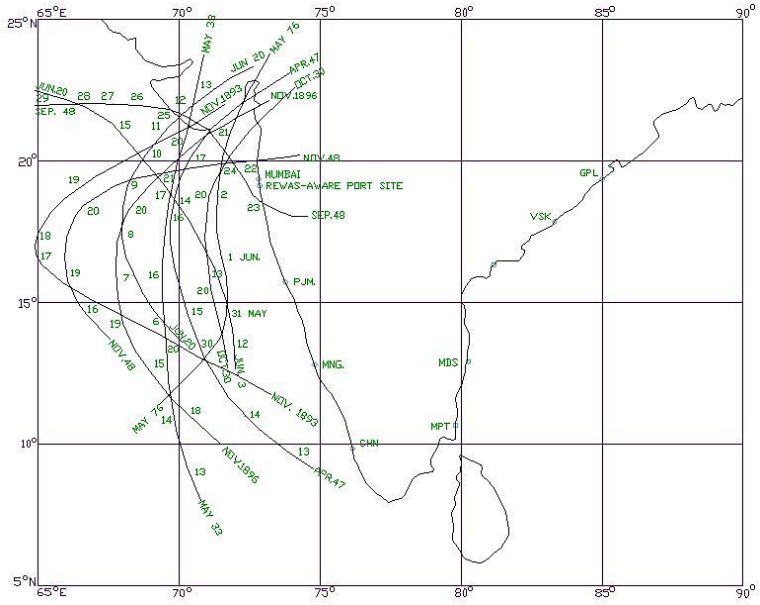


Figure 3.16: Storm tracks applicable for the region by IMD

The coastal area of Goa comes under the Moderate damage risk zone as per the Cyclone Hazard Map (Figure 3.18) prepared by Building Materials and Technology Promotion Council (BMPTC).Only two major cyclones have been reported that affected the Goa Coast. The impact of cyclonic winds is felt towards the onset of the monsoons in April end and May and again towards the flag and around September/October.

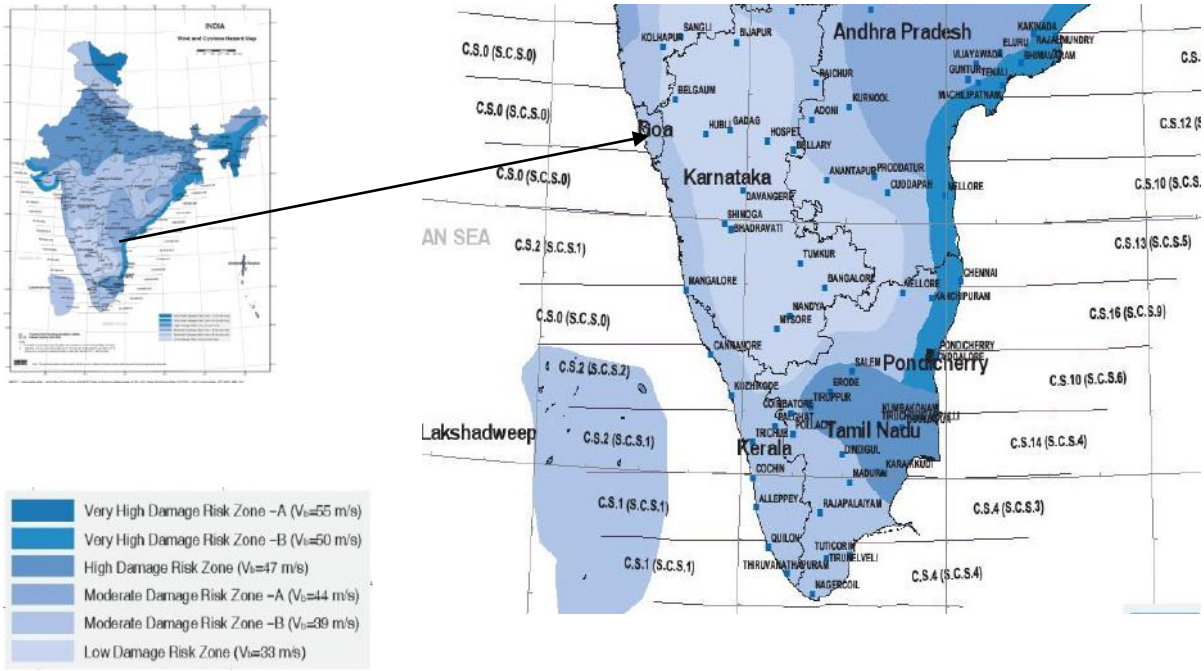


Figure 3.17: Cyclone Hazard Map of India by BMPTC

3.8.7. Flood

A number of large and small river systems drain the district and the gradient and topography of the region combined with heavy monsoons and high tide conditions caused flooding and water logging in quite a few places. The occurrence of floods, however, is restricted to the monsoons only.

3.8.8. Tsunami

As far as the Goa District is concerned, the coastal belt was not recorded any Tsunami in the past. However, the Tsunami of 26th December, 2006 in the Bay of Bengal had caused after effects in the sea and rivers.

3.9. Ambient Air Quality (AAQ)

AAQ data was monitored from seven sampling stations selected around the project site. AAQ data was monitored during March 2017 to May 2017.

Monitoring location details are delineated in Table 3.13 and the locations are shown in Figure 3.19.

Table 3.13: Ambient Air Quality Monitoring Stations Details

Sl. No.	Station Code	Location	Latitude	Longitude
1	AAQM 1	Near MPT Colony	15°24'33.39" N	73°47'12.86" E
2	AAQM 2	Vasco da Gama	15°23'46.13" N	73°48'16.58" E
3	AAQM 3	Zuari Nagar	15°23'23.87" N	73°51'50.51" E
4	AAQM 4	Cortalim	15°24'4.59" N	73°54'3.64" E
5	AAQM 5	Bambolim	15°26'21.82" N	73°52'23.85" E
6	AAQM 6	Dona Paula	15°27'33.43" N	73°48'33.70" E
7	AAQM 7	Aguada	15°29'32.20" N	73°46'21.63" E

Figure 3.18: Ambient Air Quality Monitoring Locations

Parameters like $PM_{2.5}$, PM_{10}, Sulphur dioxide (SO_2), Nitrogen Oxide (NOx) and Carbon Monoxide (CO) were measured during the monitoring period. The 24 hourly samples were collected twice a week from March 2017 to May 2017.

Summary of Ambient Air Quality Monitoring is given in Table 3.14. Laboratory monitoring results are attached as ***Annexure VI***.

Table 3.14: Results of Ambient Air Quality Monitoring

Parameters		Monitoring Stations						
		AAQ 1	AAQ 2	AAQ 3	AAQ 4	AAQ 5	AAQ 6	AAQ 7
PM 2.5 µg/m^3	Minimum	32	23	21	35	22	19	20
	Maximum	43	41	29	51	38	28	28
	Avg.	39	31	25	44	33	23	23
CPCB Standards		60 µg/m^3						
	Minimum	52	72	50	64	52	40	40

Parameters		Monitoring Stations						
		AAQ 1	AAQ 2	AAQ 3	AAQ 4	AAQ 5	AAQ 6	AAQ 7
PM_{10} $\mu g/m^3$	Maximum	75	92	65	78	72	62	47
	Avg.	63	82	59	71	62	49	43
CPCB Standards		100 $\mu g/m^3$						
SO_2 $\mu g/m^3$	Minimum	11	12	10	15	12	11	10
	Maximum	17	25	15	22	21	16	13
	Avg.	14	18	12	20	16	13	11
CPCB Standards		80 $\mu g/m^3$						
NOx $\mu g/m^3$	Minimum	19	22	13	25	21	17	10
	Maximum	27	33	21	34	31	25	20
	Avg.	23	27	17	31	26	22	17
CPCB Standards		80 $\mu g/m^3$						
CO mg/m^3	Minimum	0.8	1.1	0.8	0.3	0.4	0.6	0.5
	Maximum	1.3	1.4	1.2	1.1	1.1	1.3	0.9
	Avg.	1.1	1.3	1.0	0.7	0.7	0.9	0.8
CPCB Standards		4 mg/m^3						

Observations on $PM_{2.5}$ levels

The average concentration of $PM_{2.5}$ at various stations monitored ranged from 23-39$\mu g/m^3$. The highest $PM_{2.5}$ value was recorded as 51$\mu g/m^3$ near Shanta Durga Temple, Cortalim and lowest value of 19$\mu g/m^3$ was recorded near NIO Guest House, Dona Paula. The $PM_{2.5}$ values monitored during the field survey were within the permissible limit of 60$\mu g/m^3$ for industrial, residential, rural and other areas.

Observations on PM10 levels

It is observed that average concentration of PM_{10} at various stations ranged from 43-82 $\mu g/m^3$. The highest PM_{10} value was recorded as 92$\mu g/m^3$ near Sparkle Service Station, Vasco da Gama and lowest values of 40$\mu g/m^3$ were recorded near NIO Guest House, Dona Paula and Aguada Light House, Aguada. The average PM_{10} values monitored during the field

survey were generally within the permissible of 100µg/m^3, limits except at few occasions for industrial, residential, rural and other areas.

Observations on SO_2 levels

From ambient SO_2 level as monitored during field studies the average concentration of SO_2 at various stations in the study area was well below the prescribed limit of 80µg/m^3 specified for industrial, residential, rural and other areas. The average concentration of SO_2 at various stations monitored ranged from 11-20µg/m^3. The highest SO_2 value was recorded as 25µg/m^3 near Sparkle Service Station, Vasco da Gama and is below detectable limit in all the locations.

Observations on NOx levels

It is observed that during the study period, average NOx concentration at various sampling stations ranged from 17-31µg/m^3. The highest NOx value was recorded as 34µg/m^3 near Shanta Durga Temple, Cortalim and lowest value of 10µg/m^3 was recorded near Aguada Light House, Aguada. The average concentration of NOx at various stations in the study area was observed to be well below the prescribed limit of 80 µg/m^3 specified for industrial, residential, rural and other areas.

Observations on CO levels

The average concentration of CO at various stations monitored ranged from 0.7-1.3 mg/m^3. The highest CO value was recorded as 1.3mg/m^3 near Sparkle Service Station, Vasco da Gama and lowest value of 0.7 mg/m^3 were recorded from Shanta Durga Temple, Cortalim and Glenwood Garden Main Gate, Bambolim. The CO values monitored during the field survey were below permissible limit of 2 mg/m^3 for industrial, residential, rural and other areas.

3.10. Ambient Noise Levels

The noise levels were monitored at all AAQ stations on an hourly basis during the study period. A digital noise level meter of Lutron make was used to record the noise levels. Leq day and Leq night noise levels were derived and reported accordingly. Day time was considered as 1000 hrs to 2200 hrs and night time as 2200 hrs to 0600 hrs.

Table 3.15: Results of Ambient Noise Level Monitoring

Sl. No.	Monitoring Stations	Equivalent Noise Levels [dB (A)]		Permissible Limits
		Leq (day)	Leq (night)	
1	AAQM 1	53.5	42.8	For Industrial Area Day- 75dB(A) Night- 70dB(A)
2	AAQM 2	59.0	49.1	
3	AAQM 3	75.2	62.7	
4	AAQM 4	51.6	40.3	For Residential Area Day- 55dB(A) Night- 45dB(A)
5	AAQM 5	59.6	43.3	
6	AAQM 6	51.7	45.0	
7	AAQM 7	50.4	40.8	

It is observed that the day time equivalent noise level ranged from a minimum of 50.4 dB (A) to a maximum of 75.2 dB (A). The night time equivalent noise level ranged from a minimum of 40.3 dB (A) to a maximum of 62.7 dB (A). The proposed study area is located within the industrial area. Permissible noise limits for industrial area prescribed by CPCB are 75 dB (A) during day time and 70 dB (A) during night time. Recorded noise levels were observed to be within the required limits except at Zuari Nagar were noise level observed as 75.2 dB (A). Laboratory reports are attached as ***Annexure VII***.

3.11. Marine Biological Environment

In view of the need for conservation of environmental quality and biodiversity, study of biological environment is one of the most important components for ecological assessment. Ecological system shows inter relationship between biotic and abiotic components including dependence, competition and mutualism. Biotic component comprises of both plant and animal communities, which interact not only within and between them but also with the abiotic components viz., physical and chemical components of the environment.

Generally biological communities are the indicators of climatic conditions, dependent on environmental condition and resource of its distribution and survival. It may change if there is alteration in the environmental variables like temperature, humidity, rainfall, soil characteristics, topography etc., which are responsible for maintaining the homeostasis of the

environment. The species of flora and fauna in the environment are organized into natural communities with mutual dependencies and show various responses and sensitivies to anthropogenic influences. The changes in biotic community are studied in the pattern of distribution, abundance and diversity.

The group plankton is an important component of ecosystem, which responds to ecosystem alterations rather rapidly. It is due to the fact that planktonic organisms, which react to different types of water pollution, play a key role in turnover of organic matter and energy through the ecosystem. This reaction is very rapid because of relatively short lifetime and high reproduction rates of the organisms. Since the phytoplankton plays a key role of primary producer in aquatic environment, it is the first component in the trophic tier to be affected by pollution. Phytoplankton can grow rapidly and form massive blooms that can be regulated by environmental factors such as nutrients, availability of light and biotic interaction with grazers. Phytoplankton are passive drifters with the currents. Diatoms are a highly diverse and abundant group of phytoplankton in the aquatic environment. They are responsible for about 25% of global primary productivity and play a central role in the biogeochemical cycling of important nutrients such as carbon, nitrogen and silica. Most of the N is bound in organic compounds and its importance to phytoplankton bloom formation is well known. If bloom formations take place and then it could significantly harm these water bodies. Phytoplankton blooms decrease light penetration through the water column and can depress primary productivity. It may have diminished ecosystem integrity and the abundance and sustainability of living resources (e.g. fish and shrimp). Moreover, the bloom when dies at the end of the lifecycle of phytoplankton, they exert considerable demand on dissolved oxygen for the oxidation of organic matter and thereby deplete dissolved oxygen particularly during night time when photosynthesis is stopped.

Similarly zooplankton, also a very important group in the aquatic ecosystem, act as the primary consumer and ultimately serve as the natural food source for many aquatic organisms, including fishes. Freshwater zooplankton show considerable variety comprising of members of almost every group from protozoa to chordate. Depending on seasons and environmental conditions, the plankton community shows pronounced variation in its character and composition.

The inhabitants of a particular ecosystem serve as biological indices and reflect the environmental conditions that are required for their optimum growth and survival. In view of this, studies were carried out on distribution, diversity and other ecological aspects of phytoplankton and zooplankton from three different sampling locations of Jetty. While phytoplankton were enumerated from unfiltered water samples, desired volumes of the waters were filtered through plankton net to represent all the available groups of zooplankton. The samples were fixed immediately with 5 % buffered formalin. The parameters studied were numerical count of individual species, groups and indices, as described hereunder.

3.11.1. Phytoplankton

In the present study period, species belonging to four groups namely diatoms, dinoflagellates, blue greens and cocolithophores were recorded. Of these, diatoms were found to be the dominant group. Dinoflagellates was second dominant group followed by blue green algae Cocolithophore. Among the diatoms, *Coscinodiscus centralis, Chaetoceros affinis, Skeletonema costatum, Thalassionema nitzschioides, Triceratium favus, Cyclotella sp. Nitzschia sp. N. granulata, Pleurosigma normanii, and Rhizosolenia styliformis* were found to be the commonly occurring species in the samples collected in various stations. Coming to dinoflagellates, *Ceratium furca, C. macroceros, Protoperidinium sp and Dinophysis caudate*; blue green algae such as *Anabeana sp. and Tricodesmium erythraeum and Cocolithus sp.* were observed commonly in study area. Density of phytoplankton's varied from 2,597 to 6,064 cells/L with maximum at station-8 and minimum at station 2. Details of the phyoplanktons observed are given in Table 3.16.

Table 3.16: Phytoplankton (Cells/Liter) Recorded in Study Area

Phytoplankton	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
Cocolithophores								
Cocolithus sp.	175	0	95	0	85	220	90	225
Blue Green Algae								
Anabeana nastoc	0	110	0	90	0	0	35	350
Microcystis sp.	185	0	45	105	35	60	110	238
Tricodesmium erythraeum	110	155	0	0	0	0	90	476
Diatoms								
Bellerochea malleus	225	335	145	60	330	0	45	350
Bacteriastrum comosum	0	0	0	75	250	320	0	350
Cerataulina orientalis	75	335	65	120	110	0	220	
Chaetoceros affinis	30	330	115	120	60	180	75	310
C. indicus	150	0	0	85	33	420	0	120
C. curvisetus	0	0	105	90	40	0	150	0
Coscinodiscus centralis	750	150	110	0	425	0	0	125
C. ecentricus	0	55	0	20	125	225	90	0
C. granii	75	0	48	75	500	80	135	0
C. gigas	115	0	0	0	0	60	85	350
Dinophysis sp	0	0	0	85	95	0	110	225

Phytoplankton	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
Ditylum brightwelli	105	40	90	215	250	125	90	350
Diatoma anceps	180	0	130	0	125	225	0	0
Eucampia zoodicus	0	10	120	0	0	0	0	110
Gyrosigma balticum	138	200	75	105	0	150	125	350
Leptocylindrus danicus	0	0	0	110	180	0	90	0
Lithodesmium undulatum	350	0	125	90	120	175	120	120
N. granulata	130	10	100	200	500	0	90	0
N. seriata	145	0	215	350	330	60	0	135
Odontella mobiliensis	135	10	45	0	35	45	160	60
O. sinensis	85	0	75	0	175	0	185	210
Planktonella sol	18	90	75	0	30	30	90	0
Pleurosigma normanii	0	250	120	50	0	0	140	250
P. directum	140	0	75	75	175	330	0	0
P. elongatum	115	40	0	105	0	0	85	135
Rhizosolenia alata	0	0	90	225	330	200	120	0
R. styliformis	0	0	75	0	120	10	220	450
Skeletonema costatum	120	35	135	45	45	0	85	0
Stephanophysis palmeriana	0	0	0	0	350	155	0	80

Phytoplankton	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
Thalassionema nitzschioides	150	1250	45	120	0	10	420	110
Thalassiothrix frauenfeldii	0	420	50	120	120	120	155	0
Triceratium favus	165	220	0	105	80	0	60	220
Triceratium reticulatum	105	330	130	0	110	0	0	0
Dinoflagellates								
Ceratium furca	90	30	0	240	90	65	210	65
C. macroceros	0	0	50	0	250	250	85	0
C. tripos	90	330	75	90	0	0	120	0
Dinophysis caudata	30	0	105	0	40	110	0	80
Protoperidinium oceanicum	75	200	225	450	0	0	220	0
Pyrophagus stenii	0	220	0	165	120	220	345	220
Total	4256	5155	2953	3785	5663	3845	4450	6064

3.11.2. Zooplankton

During the study period, zooplankton groups namely Calanoida, Cyclopoida, Harpacticoida and other larval forms were recorded. Among the zooplankton, Calanoida were found to be the most dominant group. Among the Calanoida, Acartia spinicauda, Acrocalanus gibber, A. gracilis, Nannocalanus minor, Paracalanus parvus found to be the common species in the study area. Among Cyclopoida, *Oithona brevicornis, O. rigida, O. similis, Corycaeuas danae and Copilia mirabilis* were commonly observed. Among Hapacticoida *Euterpina acutiforns, Macrosetella aculata, Macrosetella gracilis, Microsetella rosea* were commonly observed. Larval forms such as Barnacle naupili, Bivalve veliger, Copepod naupili, Crustacean naupili, Gastropod veliger and Shrimp zoa were also found. The density varied from 2,615 to 7,511 nos/m^3 with maximum at Station-8 and minimum at Station-3. Details of the zooplanktons observed are given in Table 3.17.

3.11.3. Benthos

During the present investigation, four groups of benthic organisms namely polychaetes, crustaceans, bivalves and gastropods were recorded. Polychaetes constituted the dominant group followed by gastropods, crustaceans and bivalves. Among the polychaetes, *Armandia intermedia, Capitella capitella, Cossura coasta, Cirriformia sp., Goniada emerita, Lumbrinereis sp., Notomastus aberrans, Nereissp.,Ophelia sp., Perineries sp.* were found to be the most commonly occurring species in the study area.

The population density varied from 153 to 90 nos/m2 with maximum at station-2 and minimum at station-3. Intertidal stations showed low population at Project site (52 nos./m2). Details are given in Table 3.18.

Table 3.17: Zooplanktons (nos/m^3) Recorded in Study Area

Zooplankton	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
Calanoida								
Acartia spinicauda	360	130	80	0	110	0	0	125
A. erythrea	350	0	350	50	0	425	520	525
Acrocalanus gipper	35	0	350	350	25	205	0	310
A. gracilis	540	300	0	45	0	0	600	410
Cenropages furcatus	0	0	85	350	160	225	0	615
Nannocalanus minor	0	120	120	350	50	40	0	0
Paracalanus parvus	150	450	120	40	0	320	0	205
Pontella danae	350	375	25	0	0		282	525
Temora turbinata	0	340	0	0	0	0	0	0
Cyclopoida								
Oithona brevicornis	128	715	0	350	595	0	282	600
O. rigida	20	0	40	50	355	410	125	0
O. similis	350	560	0	120	0	0	135	240
Corycaeuas danae	0	0	125	350	0	595	0	325
Copilia mirabilis	80	120	350	0	20	45	225	350

Zooplankton	**MW1**	**MW2**	**MW3**	**MW4**	**MW5**	**MW6**	**MW7**	**MW8**
Harpacticoida								
Euterpina acutiforns	55	308	30	224	0	0	225	840
Macrosetella aculata	120	410	0	0	325	816	0	540
Macrosetella gracilis	325	615	0	225	0	410	145	0
Microsetella rosea	70	0	350	0	0	0	224	0
Spirotricha								
Favella brevis	40	120	0	0	225	350	225	350
F. philipiensis	350	350	0	450	350	238	0	0
Tintinnopsis cylindrica	25	0	30	540	0	125	225	540
T. tocantinensis	20	0	225	0	350	350	135	0
Tintinnopsis tubulosa	540	130	0	350	125	320	60	110
Others								
Lucifer hanseni	0	60	40	20	120	0	350	0
Sagitta sp	125	30	45	350	155	0	0	85
Oikopleura dioica	150	350	0	0	70	350	90	45
Oikopleura parva	125	125	150	35	0	0	50	420
Larval forms								
Barnacle naupili	75	350	20	0	0	60	0	0

Zooplankton	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8
Bivalve veliger	120	320	0	45	0	120	350	110
Copepod naupili	0	0	0	0	350	0	60	0
Crustacean naupili	350	75	35	350	225	60	0	0
Gastropod veliger	225	130	0	0	0	0	745	120
Shrimp zoa	70	0	45	350	25	0	75	120
Total	**5148**	**6483**	**2615**	**4994**	**3635**	**5464**	**5128**	**7510**

Table 3.18: Benthos (nos/m^2) Recorded in Study Area

Benthos	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8	IT1	IT2
Polychaetes										
Armandia intermedia	0	0	3	3	0	0	3	8	3	3
Armandia longicaudata	5	5	0	3	5	0	3	0	5	3
Boccardia polybranchia	0	13	0	0	0	0	0	0	3	6
Exogone clavator	5	0	3	0	5	0	0	0	5	2
Goniada emerita	0	0	5	0	3	0	0	5	0	1
Lumbrineri ssp.	8	10	0	0	0	13	0	0	2	8
Lumbrineris heteropoda	0	0	8	0	3	0	0	0	1	4

Nephtys dibranchis	5	5	0	5	0	0	5	0	0	5
Nephtys hombergi	0	8	3	5	8	0	5	3	0	0
Nereis sp.	8	0	0	0	0	10	0	0	0	0
Notomastus aberans	0	5	0	3	3	3	3	5	0	1
Perinereis capensis	0	0	8	0	0	3	0	0	0	1
Pisione africana	0	0	0	0	0	0	0	3	0	7
Platynereis calodonta	3	0	0	8	0	0	8	0	2	1
Platynereis sp.	0	0	5	5	3	5	5	10	1	1
Polydora ciliata	0	3	0	3	0	3	3	0	5	1
Prionospio capensis	0	0	5	0	0	0	0	0	1	3
Prionospio cirrifera	5	0	0	3	5	0	3	0	2	5
Prionospio pinnata	10	8	0	0	5	8	0	0	3	0
Syllis sp.	0	0	0	10	0	5	10	10	0	0
Bivalves	0	0	0	0	0	0	0	0	0	0
Anadara veligers	0	10	0	5	0	10	5	0	0	0
Cardium veligers	0	0	8	0	5	0	0	13	2	22
Donax veligers	13	0	8	0	0	0	0	5	4	26
Meretrix veligers	0	13	0	8	8	13	8	0	2	0
Gastropods	0	0	0	0	0	0	0	0	0	25

Bullia veligers	0	0	3	0	0	0	0	18	1	0
Cerithidea cingulata	0	13	0	0	0	18	0	0	0	0
Littorina veligers	10	0	0	15	8	10	15	10	5	0
Nassarius variegatus	5	10	5	0	0	0	0	0	5	4
Natica veligers	5	0	0	5	0	5	5	0	0	0
Turris veligers	0	10	3	0	3	0	0	3	0	6
Crustaceans	0	0	0	0	0	0	0	0	0	0
Ampithoe rubricata	13	0	10	0	10	0	0	0	0	12
Ampithoe romondi	18	20	5	5	20	0	5	15	0	22
Angeliera phreaticola	0	0	0	0	0	10	0	0	0	20
Campylaspis sp.	15	10	13	13	15	23	13	8	0	6
Gammarus sp.	5	13	0	5	15	5	5	10	0	6
Total	**130**	**153**	**90**	**100**	**120**	**140**	**100**	**123**	**52**	**201**

3.12. Terrestrial Ecology

3.12.1. Forest Types in Goa

The State of Goa has more than 33% of its geographic area under government forests (1224.38 sq.km.) of which about 62% has been brought under Protected Areas of Wildlife Sanctuaries and National Park. Since there is a substantial area under private forests and a large tract under cashew, mango, coconut, etc. plantations the total forest and tree cover constitute 56.6% of the geographic area.

The forests of Goa are typical of the Western Ghats. There is diversity in the forests due to the variation in altitude, aspect, soil characters, slope etc. As per Champion and Seth (1968) Classification of Forest types of India, the forests of Goa within 15 km radius from project site fall in the following types:-

(A) Estuarine vegetation consisting of mangrove species along narrow muddy banks of rivers

[4 B/TS1 and 4B/TS2]

(B) Strand vegetation along the coastal belts

(C) Plateau vegetation confined especially to the low altitude

- x Open scrub jungle (5.E7)
- x Moist mixed deciduous forests [3B/C2]
- x Secondary moist mixed deciduous forests [3B/C2/2SI)
- x Sub-tropical Hill forests [8A/C2]

Estuarine vegetation

Mangroves along swampy river banks [4 B/TS1 and 4B/TS2]:- This type occurs in isolated small patches along the banks of Mandovi and Zuari rivers and other salt water streams. Botanically this zone is characterized by peculiar root formations (stilt roots of Rhizophora, pneumatophores in Avicennia, knee root in Bruguiera etc). The mangroves are found in the division mainly at Durbhat, Panaji, Agassaim and Cortalim. The above categories of vegetation occur from sea level to 100m.

Strand and creek vegetation

Most of the coastal regions of Goa are rocky with projecting ridges. The strand vegetation is limited to a few patches of narrow strip bordering the Arabian Sea. The vegetation along the south bank of the river Zuari near Vasco belongs to this category. Tree species mainly found are Pongamia pinnata, Thespesia pupulnea, Calophyllum inophyllum, Cerbera manghas and Pandanus tectorius. Many herbaceous species such as Neanotis rheedei, lphigenia indica, Begonia crenata, Mitreola oldenlandioides, Habenaria grandifloriformis, Tricholepis glaberrima, Trichidesma sp. are found along rocky creeks and projecting ridges facing the coast.

Plateau vegetation

A major portion of the vegetation in Goa belongs to this category, which is further divided into two types viz. (a) Open Scurb jungle and (b) Moist deciduous forests.

(a) Open scrub jungle (5.E7): This type of vegetation occurs from Panaji to Cortalim and from Bicholim to Sanquelim. Anacardium occidentale is found on an extensive scale. The vegetation is mainly composed of dry deciduous elements such as Carissa congesta, Hollarrhena pubescens, Lantana camara, Calycopteris floribunda, Woodfordia fruticosa, Grewia abutilifolia, Vitex negundo and species of Calotropis, Ziziphus, Cassia, Ixora, Acacia, Albizia, Terminalia and Crotalaria.

(b) Moist mixed deciduous forests [3B/C2]: - This is the main forest type, found in Goa, covering more than half of the forest areas. Predominant species are Terminalia crenulata, T. belerica, T. paniculata, Lagerstroemia parviflora, Adina cordifolia, Albizia lebbeck, A. procera, Mitragyna parvifolia, Holoptelia integrifolia, Trewia nudiflora, Dillenia pentagyna, Semicarpus anacardium, Mallotus philippensis and Stereospermum colais.

Urban Area

All major settlements are either situated near coastline or surrounded by agricultural fields. Vegetation in urban area is dominated by native as well as exotic species such as Cocos nucifera, Azadirachta indica, Delonix regia, Ficus spp and Zizyphus mauritiana.

Agricultural Area

The staple produce of Goa is Rice (Oriza sativa) followed by coconut (Cocos nucifera) which accounts for variety of uses to which their products are applied. Coconuts are grown abundantly in groves all along the coastal stretch of the state, at many places interspersed with horticultural plantations. Inferior soils are used for cultivation of cereals and pulses as Nachne (Eleusine coracanal), Urid (Phaseolus radiatus), Culit (Dolichus uniflorus),Orio (Panicum miliaceum), Mug (Phaseolus mungo), and Tori (Cajanus indicus). Among orchards most important are the mango (Mangifera indica), jackfruit (Artocarpus integrifolia), Cashew (Anacardium occidentale), and Banana (Musa paradisiacal). Till (Sesamum indicum) and Son (Crotolaria juncea) are major oil plants. Vegetables like Potatoes (Convolvulus batatas), Radishes (Raphanus sativus), Yams (Dioscrea sativa), Ladyfingers (Abelmoschus esculentus), Melons (Cucumis melo), watermelons (Cucurbita citrillus), cucumbers (Cucumis sativus), pumpkins (Cucurbita pepo), bottle gourds (Cucurbita lagenaria), and Snake gourds (Trichosanthes anguina) are most commonly cultivated. Besides these, Chillies (Capsicum frutescens), Ginger (Zingiber officinale), Turmeric (Curcuma longa) Onions (Allium Cepa), and Tirphal (Zanthoxylum rhetsa) are commonly used spices.

Scrubs

The remaining area other than arable land is open scrub. Flora of scrubs is dominated by Memecelon umbellatum, Calotropis gigantia and Lantana camera. Caryota urens was also quite common in the relatively undisturbed natural areas, but never occurred gregariously.

3.12.2. Methodology of Ecological Survey

The study area was divisible into three zones on the basis of their distance from the project site: Zone I – 0 km to 2.5 km from the project-site, Zone II – 2.5 km to 5 km from the project-site and Zone III – 5 km to 10 km from the project-site. Ecological surveys were conducted at selected sites in each zone. Sites were so selected that maximum types of habitats are covered. Four sites were selected in zone I. Five sites were selected in zone II and five sites were selected in zone III. At each site, a study of floral diversity was carried out in the following manner: A quadrat of approximately 20 m x 20 m was marked. The species of trees, shrubs and large climbers, as well as the number of individuals of each species, falling within this area were noted. A quadrat of approximately 5 m x 5 m was marked within this

larger quadrat. The species of herbs, both grasses and forbs, and the number of individuals of each species, falling within this area were noted.

At each site, faunal diversity was studied through direct evidence, in the form of visual sightings, and indirect evidence such as calls, nests, burrows, droppings, scats, tracks etc. All available types of habitats at the site were evaluated and marked. These areas were visited at specific times when most bird activity is expected i.e. early morning – noon and late afternoon – late evening (for crepuscular birds). The activities of birds and animals were observed during this time and an exhaustive list of the birds seen was prepared. The birds were identified and confirmed with their unique calls wherever they were not observed directly.

3.12.3. Flora

In general, flora of study region was observed to be healthy and highly diverse. No distinct variation was observed in vegetation from zone to zone. However, variations were observed in habitats. Vegetation near villages and along the roads was represented by trees and shrubs, while sand dunes were dominated by climbers. Flora on platue was dominated by scrubs. Mangroves were observed near intertidal regions of Zuari River. No reserve forest areas were observed in study area. All over 38 tree species were recorded in study region. Diversity of non-woody flora or herbs was recorded to be low due to summer season. However, earlier studies showed that variety of wild flowers in this region is very high (Ingalhalikar, 2008).

The area in immediate vicinity of project site showed urban vegetation. Tree species were dominated by Cocos nucifera, Memecelon umbellatum, Grewia tilifolia, Anacardium occidentale and Mangifera indica. Flora in Zone II exhibited maximum diversity and was dominated by species like A. occidentale, M. indica, Tamarindus indicus and Tectona grandis. However, density of coconut plants was observed to be highest due to occurrence of agricultural fields. The Zuari River, agricultural fields, open scrubs and human settlements were present in this zone.

Zone III was majorly represented by river, agricultural area and beach. Flora of zone III did not show any variation from that of zone II. Beach flora was dominated by I. pes-caprae, S. littoreus and L. camera. Flora near agricultural land was dominated by Bombax ceiba, Butea monosperma, C. floribunda, C. urens and Holarrhena antidysenterica.

	
Calycopteris floribunda	Lannea coromandelica
	
Anacardium occidentale	Grewia tilifolia
	
Tectona grandis	Tamarindus indicus
	
Butea monosperma	Bombax ceiba

Table 3.19: Flora Observed in Study Area

Species	Family	% FO			Density per ha			Abundance		
		Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Anacardium occidentale	Anacardiaceae	100	100	30	87.5	119.17	60.54	3.5	3.18	1.94
Argemone mexicana	Papaveraceae	50	20.19	11.67	12.5	17.08	42.46	0.5	0.46	1.36
Atlantia racemosa	Rutaceae	50	68.33	15	12.5	38.75	30.04	0.5	1.03	0.96
Bombax ceiba	Bombacaceae	50	51.85	100	18.75	42.71	70.39	0.75	1.14	2.25
Butea monosperma	Fabaceae	50	70.19	100	25	54.58	79.58	1	1.46	2.55
Calycopteris floribunda	Combretaceae	75	51.67	100	93.75	65.63	237.5	3.75	1.75	7.6
Caryota urens	Araceae	75	70.19	100	68.75	118.54	127.17	2.75	3.16	4.07
Cayratia auriculata	Verbinaceae	50	36.85	8.33	12.5	27.92	32.9	0.5	0.74	1.05
Celastrus paniculatus	Celastraceae	25	36.85	38.33	6.25	17.08	24.45	0.25	0.46	0.78
Cocculus hirsutus	Menispemaceae	50	36.67	40	12.5	25.63	50.77	0.5	0.68	1.62
Cocos nucifera	Araceae	100	70.19	100	125	214.79	145.52	5	5.73	4.66
Colubrina asiatica	Rhamnaceae	25	20.19	11.67	12.5	23.33	49	0.5	0.62	1.57
Diploclisia glaucescens	Menispemaceae	25	20.19	10	6.25	8.54	14.35	0.25	0.23	0.46
Ficus benghalensis	Moraceae	50	18.33	13.33	25	20	42.02	1	0.53	1.34

Ficus religiosa	Moraceae	25	51.67	18.33	6.25	36.25	40.79	0.25	0.97	1.31
Garuga pinnata	Burseraceae	50	1.67	31.67	18.75	3.75	13.2	0.75	0.1	0.42
Grewia tiliifolia	Tiliaceae	75	16.67	35	43.75	6.25	47.4	1.75	0.17	1.52
Helicteres isora	Sterculiaceae	75	18.33	100	56.25	7.5	57.2	2.25	0.2	1.83
Hiptage benghalensis	Malpighiaceae	50	16.67	55	31.25	6.25	30.88	1.25	0.17	0.99
Holarrhena antidysenterica	Apocynaceae	75	53.52	100	50	37.08	82.54	2	0.99	2.64
Lannea coromandelica	Anacardiaceae	100	53.52	90	125	52.92	45.63	5	1.41	1.46
Lantana camera	Verbinaceae	100	85	100	93.75	96.88	110.79	3.75	2.58	3.55
Mangifera indica	Anacardiaceae	100	85.19	100	118.75	144.79	73.74	4.75	3.86	2.36
Memecylon umbellatum	Melastomaceae	100	36.85	73.33	118.75	28.54	30.63	4.75	0.76	0.98
Miliusa tomentosa	Annonaceae	100	70	41.67	143.75	73.13	27.31	5.75	1.95	0.87
Murraya koenigii	Rutaceae	25	70	3.33	12.5	64.38	9.08	0.5	1.72	0.29
Nothopegia beddomei	Anacardiaceae	0	36.67	3.33	0	25.63	3.72	0	0.68	0.12
Pterospermum diversifolium	Sterculiaceae	0	36.85	8.33	0	34.17	6.18	0	0.91	0.2
Sterculia urens	Sterculiaceae	50	50	13.33	12.5	37.5	14.88	0.5	1	0.48
Tamarindus indicus	Fabaceae	50	86.85	13.33	18.75	141.04	72.44	0.75	3.76	2.32
Tectona grandis	Verbinaceae	50	86.67	21.67	18.75	95.63	56.41	0.75	2.55	1.81
Terminalia belerica	Combretaceae	50	68.52	28.33	12.5	72.92	28.2	0.5	1.94	0.9

Terminalia paniculata	Combretaceae	75	70.19	26.67	50	51.67	25.03	2	1.38	0.8
Terminalia tomentosa	Combretaceae	75	51.67	16.67	43.75	53.75	19.23	1.75	1.43	0.62
Thespesia lampas	Malvaceae	25	20.19	13.33	6.25	27.92	36.25	0.25	0.74	1.16
Thespesia populnea	Malvaceae	25	36.85	100	12.5	90.42	113.85	0.5	2.41	3.64
Vitex nigundo	Verbinaceae	50	70	100	31.25	43.13	74.86	1.25	1.15	2.4
Ziziphus mauritiana	Rhamnaceae	50	70.19	100	50	136.67	230.57	2	3.64	7.38

3.12.4. Fauna

Avifauna

The first ornithological study in Goa was conducted by Grubh and Ali (1976). During their surveys they collected 150 specimens of 100 species and sight-recorded 54 species. Later, Rane (1984) added 33 species. Saha and Dasgupta (1992) compiled a checklist of 208 species. Based on 13 years of fairly intensive field studies and about 1300 field trips, Lainer (1999a, b) recorded 382 species.

Overall 80 species of birds were observed in various habitats among study area during survey period. Water bodies like rivers and creeks were inhabited by Egrets, Cormorants, Herons, Ibis and Sand Pipers. Two species of kingfishers were recorded. Terns, Godwits and Redshanks were occasionally seen near small streams pouring into Zuari River.

Agricultural fields and open scrubs were dominated by Dove, Cuckoo, Koyal, Larks, Bee Eaters, Swifts and Swallows. Predators and accipiter like Black Kite, Black Shouldered Kite and Brahminy Kite were commonly seen on hunting for small birds. Nesting sites of White Bellied Sea Eagle were commonly observed along coastline. White Bellied Sea Eagle is declared as Scheduled I species wide Wildlife Protection Act, 1972.

A garbage dumping ground of Vasco da Gama city was observed to be huge feeding ground for kites. Small birds like Oriole, Koel, Huppoe, Drongo, Myna, Bulbul and Babblers dominated dense vegetation. No threatened or endangered species of birds were recorded from study area.

Table 3.20: Avifauna Observed in Study Area

Common Name	Scientific Name	Habit	IUCN Redlist Status WPA Schedule
Great Cormorant	Phalacrocorax carbo	R	LC/Schedule IV
Little Cormorant	Phalacrocorax niger	R	LC/Schedule IV
Indian Cormorant	Phalacrocorax fuscicullis	R	LC/Schedule IV
Great Egret	Casmerodius albus	R	LC/Schedule IV
Intermediate Egret	Mesophoyx intermedia	R	LC/Schedule IV
Little Egret	Egretta garzetta	R	LC/Schedule IV

Western Reef Egret	Egretta gularis	R	LC/Schedule IV
Cattle Egret	Bubulcus ibis	R	LC/Schedule IV
Grey Heron	Ardea goliath	R	LC/Schedule IV
Purple Heron	Ardea purpurea	R	LC/Schedule IV
Little Heron	Butorides striatus	R	LC/Schedule IV
Indian Pond Heron	Ardeola grayii	R	LC/Schedule IV
Black Headed Ibis	Threskiornis melanocephalus	R	LC/Schedule IV
Glossy Ibis	Plegadis falcinellus	R	LC/Schedule IV
Black Kite	Milvus migrans	R	LC/Schedule IV
Black Eared Kite	Milvus migrans lineatus	M	LC/Schedule IV
Brahminy Kite	Haliastur Indus	R	LC/Schedule IV
White-bellied Sea-eagle	Haliaeetus leucogaster	R	LC/Schedule I
Laggar Falcon	Falco jugger	R	LC/Schedule IV
Peregrine Falcon	Falco peregrinus calidus	M	LC/Schedule IV
White Breasted Water Hen	Amaurornis phoenicurus	R	LC/Schedule IV
Common Coot	Fulica atra	R	LC/Schedule IV
Black Winged Stilts	Himantopus himantopus	R	LC/Schedule IV
Red Wattled Lapwing	Vanellus indicus	R	LC/Schedule IV
Little Ringed Plover	Charadrius dubius	R	LC/Schedule IV
Kentish Plover	Charadrius alexandrius	M	LC/Schedule IV
Black Tailed Godwit	Limosa limosa	M	LC/Schedule IV
Marsh Sandpiper	Tringa stagnatilis	M	LC/Schedule IV
Wood Sandpiper	Tringa glareola	M	LC/Schedule IV
Green Sandpiper	Tringa ocropus	M	LC/Schedule IV
Common Sandpiper	Actitis hypoleucos	M	LC/Schedule IV
River Tern	Sterna aurantia	R	LC/Schedule IV
Gull Billed Tern	Gelochelidon nilotica	M	LC/Schedule IV
Whiskered tern	Chlidonias hybridus	M	LC/Schedule IV
Euarasian Collared Dove	Streptopelia decaocto	R	LC/Schedule IV
Laughing Dove	Streptopelia senegalensis	R	LC/Schedule IV

Spotted Dove	Streptopelia chinensis	R	LC/Schedule IV
Rock Pigeon	Columba livia	R	LC/Schedule IV
Indian Rosering Parakit	Psittakula krameri	R	LC/Schedule IV
Eurasian Cuckoo	Cuculus canorus	M	LC/Schedule IV
Greater Coucal	Centropus sinensis	R	LC/Schedule IV
Asian Koel	Chrysococcyx maculatus	R	LC/Schedule IV
Spotted Owlet	Athene brama	R	LC/Schedule IV
House swift	Apun affinis	R	LC/Schedule IV
Asian Palm Swift	Cypsiurus balasinensis	R	LC/Schedule IV
White Throated Kingfisher	Halcyon pileata	R	LC/Schedule IV
Small Blue Kingfisher	Alcedo attbis	R	LC/Schedule IV
Blue Cheeked Bee-eater	Meropus persicus	M	LC/Schedule IV
Blue Tailed Bee-eater	Meropus philippinus	M	LC/Schedule IV
Green Bee-eater	Meropus orientalis	R	LC/Schedule IV
Common Hoopoe	Upupa epops	R	LC/Schedule IV
Eurasian Golden Oriole	Oriolus oriolus	R	LC/Schedule IV
Ashy Crown Sparrow Lark	Erimopterix grisea	R	LC/Schedule IV
Rufous Tailed Lark	Ammommanes cinctures	R	LC/Schedule IV
Oriental Skylark	Alauda gulgula	R	LC/Schedule IV
Sand Lark	Calandrella raytal	R	LC/Schedule IV
Crested Lark	calandrella crestata	R	LC/Schedule IV
Barn Swallow	Hirundo rustica	M	LC/Schedule IV
Wire Tailed Swallow	Hirundo smithii	R	LC/Schedule IV
Black Drongo	Dicrirus macrocercus	R	LC/Schedule IV
Long Tailed Shrike	Laniaus schach	R	LC/Schedule IV
Brahminy Starling	Strunus pagodarum	R	LC/Schedule IV
Bank Myna	Acridotheres ginginianus	R	LC/Schedule IV
Common Myna	Acridotheres tristis	R	LC/Schedule IV
Large Billed crow	Corvus macrorbynchos	R	LC/Schedule IV
House Crow	Corvus splendens	R	LC/Schedule IV

Red Vented Bulbul	Pycnonotus cafer	R	LC/Schedule IV
Red Whiskered Bulbul	Pycnonotus jocosus	R	LC/Schedule IV
Large Grey Babbler	Terdoides malcolmi	R	LC/Schedule IV
Jungle Babbler	Terdoides striatus	R	LC/Schedule IV
Clamorous Reed Wabler	Acrocephalus stentoreus	M	LC/Schedule IV
Booted Wabler	Hippolais caligata	M	LC/Schedule IV
Sykes's Wabler	Hippolais rama	M	LC/Schedule IV
Oriental Magpie Robin	Copsychus saularis	R	LC/Schedule IV
Siberia Stonechat	Saxycola torquata	M	LC/Schedule IV
Peid Stonechat	Saxycola caprata	M (Local)	LC/Schedule IV
Grey Wagtail	Motacilla cinerea	M	LC/Schedule IV
White Wagtail	Motacilla alba	M	LC/Schedule IV
Scaly Breasted Munia	Nonchura punchulata	R	LC/Schedule IV
House Sparrow	Passsel domesticus	R	LC/Schedule IV

Legend: R – Resident, M – Migratory, LC – Least Concerned

Mammals

Due to absence of dense vegetation mammalian density of this region was observed to be very low. No schedule I species was recorded from entire study area. Moreover, forest cover map of Goa shows that this region do not comprise any major forest range or block. Hence, no wildlife data pertaining to this region is available.

However, Mongoose (Schedule II) and Three Striped Squirrels (Schedule IV) were commonly seen during survey. Local villagers confirmed the presence of Jungle Cat (Schedule II) common Indian wild hare (Schedule IV) in study area.

Reptiles

Class reptilian in study area is represented by loricata (crocodiles, gharials, alligators, etc), testudines (turtles, tortoises and terrapins) and squamata (lizards, snakes). Loricata species include Indian or marsh crocodile. Crocodiles have found an ideal habitat in the Cumbarjua canal and mangrove swamps. However, the habitat of marsh crocodile is considerably away from proposed project site. The turtles of study area include loggerhead sea turtle, green sea turtle, hawksbill sea turtle or tortoise shell turtle and leatherback sea turtle. All these are

marine turtle species. The geckos of study area include south Indian rock gecko, north Malabar rock gecko, south Malabar rock gecko, dark spotted giant gecko, blotched gecko, spotted house gecko, Prashad brown gecko, reticulated gecko, Ticticky house gecko, common bark gecko and yellow bellied house gecko.

Study area has five lizards and a single chameleon (shedde) species. These include south Indian flying dragon or flying lizard, Indian fan-throated lizard, Indian garden lizard, olive brown rock lizard and Indian chameleon. The chameleons appear during monsoon and can be seen feasting on grasshoppers and beetles. The nonpoisonous variety of snakes include the common blind snake, the Russell sand boa, the Indian python, the Indian wart snake, trinket snake, Indian rat snake, golden tree snake, common wolf snake, chequered keelback, striped keelback, Indian gamma and common green whip snake. Among the few venomous snakes in Study area are the cobras, common Indian krait, coral snake, Russell's viper, saw-scaled viper and bamboo pit viper.

3.13. Socio Economic Environment

This section discusses the baseline scenario of the socio-economic environment in the study area and anticipated impacts of the proposed project on the socio-economic environment. Socio-economic assessment of the study area has been prepared based on secondary data extracted from Primary Census Abstract, Census of India 2011. The issues under focus in this topic are demographic pattern, economic activity, education and literacy profile, etc. The assessment attempts to predict and evaluate the future impacts of project upon people, their physical and psychological health and well-being, their economic status, cultural heritage, lifestyle and other value system.

The study area of the proposed project is spread over two Sub district namely Tiswadi of North Goa and Murmagao of South Goa districts, respectively. The study area settlements consist of Municipal Corporation Wards/Census Towns/Villages.

3.13.1. Demographic Profile

The study area comprises of 40 settlements, including 20 Municipal Corporation wards, 8 Census towns, 8 rural villages and 4 out growths. The total population in the study area includes 314986 persons, of which, about 10.02% comprises of children below the age of 6

years as per Census of India 2011. The distribution of population and demographic profile of study area is shown in Table 3.21 and illustrated in Figure 3.20.

Table 3.21: Population Details of Study Area

Sr. No	Name of Settlements	Total Household	Total Population	Total Male	Total Female	Population<6 years	Average Sex Ratio
	District North Goa Sub district Tiswadi						
1	Batim	356	1489	739	750	132	1015
2	Curca	560	2518	1232	1286	256	1044
3	Siridao	578	2417	1179	1238	218	1050
4	Panaji	17807	70991	35988	35003	6180	973
5	Cujira	296	1229	601	628	122	1045
6	Taleigao	6003	24201	12402	11799	2356	951
7	Durgawadi	388	1610	830	780	180	940
8	Murda (CT)	1803	7517	3699	3818	782	1032
9	Calapor (CT)	3514	14077	7118	6959	1443	978
10	Bambolim (CT)	1165	6885	4812	2073	525	431
11	Mercurim (CT)	1233	4970	2329	2641	521	1134
12	Goa Velha (CT)	1055	4322	2129	2193	427	1030
	Subtotal (X)	34758	142226	73058	69168	13142	968
	District South Goa Sub District Mormugao						
12	Dabolim	1433	6027	3142	2885	699	918
13	Sao Jacinto Island	48	195	104	91	16	875
14	Pale	473	1990	1010	980	202	932
15	Issorcim	189	841	434	407	61	938
16	Chicolna	669	2680	1350	1330	274	985
17	Sao Jorge Island	No Habitation					

Sr. No	Name of Settlements	Total Household	Total Population	Total Male	Total Female	Population<6 years	Average Sex Ratio
	Mormugao						
18	(M Cl) WARD NO.-0001	675	3659	2483	1176	175	474
19	(M Cl) WARD NO.-0002	599	2518	1293	1225	205	947
20	(M Cl) WARD NO.-0003	675	3071	1566	1505	316	961
21	(M Cl) WARD NO.-0004	834	3852	2116	1736	378	820
22	(M Cl) WARD NO.-0005	990	4462	2356	2106	476	894
23	(M Cl) WARD NO.-0006	905	4059	2039	2020	425	991
24	(M Cl) WARD NO.-0007	746	3428	1814	1614	439	890
25	(M Cl) WARD NO.-0008	968	4791	2480	2311	624	932
26	(M Cl) WARD NO.-0009	1228	5507	2896	2611	595	902
27	(M Cl) WARD NO.-0010	1020	4387	2240	2147	391	958
28	(M Cl) WARD NO.-0011	494	1954	988	966	169	978
29	(M Cl) WARD NO.-0012	835	3897	2012	1885	435	937
30	(M Cl) WARD NO.-0013	922	4175	2197	1978	426	900
31	(M Cl) WARD NO.-0014	933	4103	2099	2004	346	955
32	(M Cl) WARD NO.-0015	1103	5661	3058	2603	707	851
33	(M Cl) WARD NO.-0016	1244	5171	2711	2460	531	907
34	(M Cl) WARD NO.-0017	1420	6061	3150	2911	710	924
35	(M Cl) WARD NO.-0018	2904	11104	5754	5350	1419	930
36	(M Cl) WARD NO.-0019	1006	4517	2312	2205	526	954
37	(M Cl) WARD NO.-0020	2023	8016	4069	3947	732	970
38	Chicalim (CT)	1483	6933	3921	3012	618	768
39	Sancoale (CT)	5035	21923	11657	10266	2693	881
40	Cortalim (CT)	2319	9080	4796	4284	968	893

Sr. No	Name of Settlements	Total Household	Total Population	Total Male	Total Female	Population<6 years	Average Sex Ratio
	Subtotal (Y)	33173	144062	76047	68015	15556	902
	Total (X+Y)	67931	286288	149105	137183	28698	922

Source: Primary Census Abstract, 2011

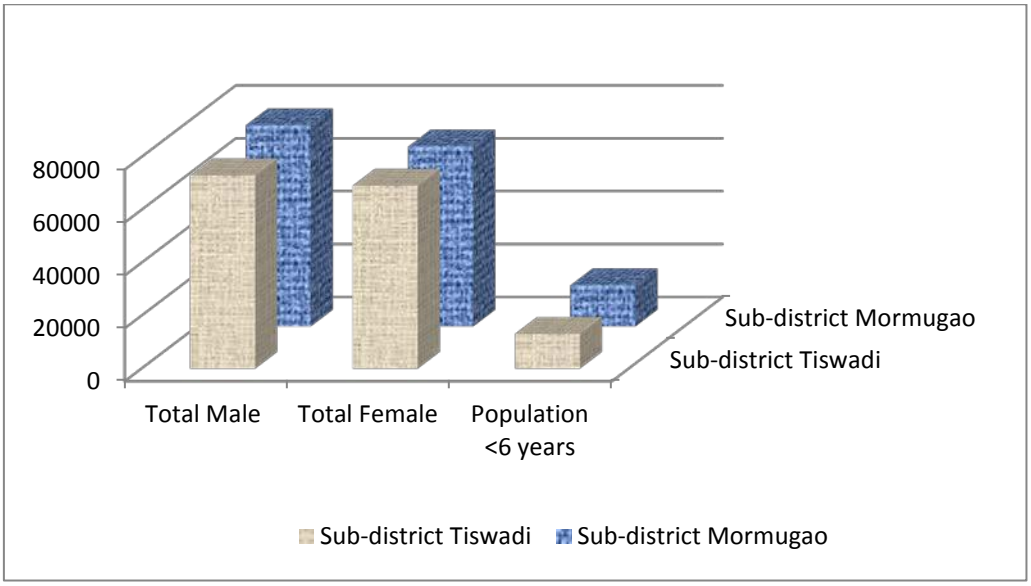


Figure 3.19: Demographic profile in Study Area

The male population consists of 52.08% and female population consists of 47.92% of the total population. The overall sex ratio, i.e. number of females per 1000 males is 922.

Caste Profile

The distribution of population in study area settlements on the basis of caste is summarized in Table 3.22 and showed in Figure 3.21. The General caste dominate in the study area of about 92.05% of the total population followed by Schedule Tribes, of about 5.82% and Schedule Castes nearly 2.12% of the total population in the Study Area.

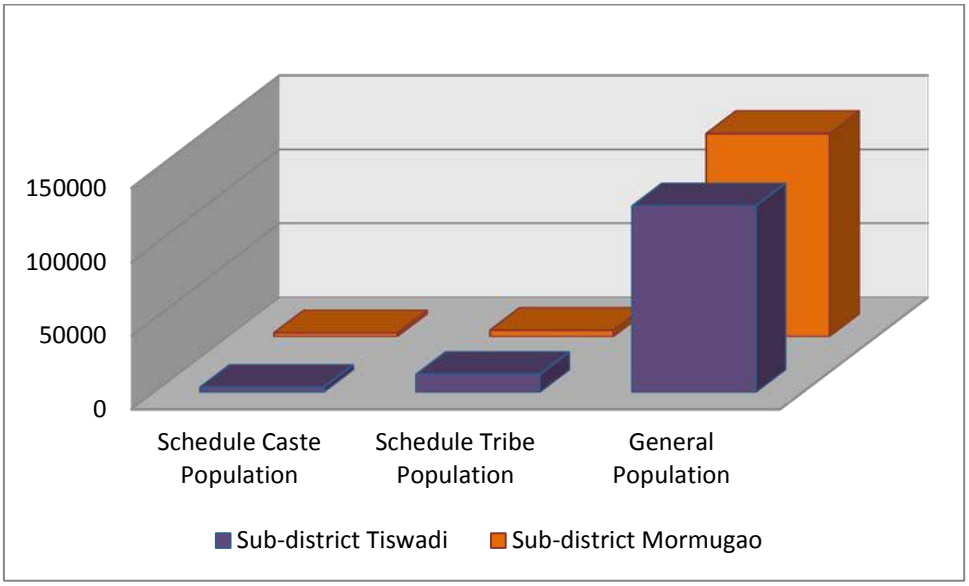


Figure 3.20: Caste profile in Study Area

Table 3.22: Caste profile in the study area

Sr. No	Name of Settlements	Total Population	Schedule Caste Population	Schedule Tribe Population	General Population
	District North Goa Sub district Tiswadi				
1	Batim	1489	12	21	1456
2	Curca	2518	11	497	2010
3	Siridao	2417	0	1265	1152
4	Panaji (M Corp. + OG)	70991	1707	4586	64698
5	Cujira (OG)	1229	4	1	1224
6	Taleigao (OG)	24201	1097	2869	20235
7	Durgawadi (OG)	1610	29	25	1556
8	Murda (CT)	7517	81	314	7122
9	Calapor (CT)	14077	427	1211	12439
10	Bambolim (CT)	6885	172	839	5874
11	Mercurim (CT)	4970	14	602	4354

Sr. No	Name of Settlements	Total Population	Schedule Caste Population	Schedule Tribe Population	General Population
12	Goa Velha (CT)	4322	20	116	4186
	Subtotal (X)	142226	3574	12346	126306
	District South Goa Sub district Mormugao				
12	Dabolim	6027	65	307	5655
13	Sao Jacinto Island	195	0	0	195
14	Pale	1990	6	76	1908
15	Issorcim	841	4	5	832
16	Chicolna	2680	45	376	2259
17	Sao Jorge Island	No Habitation			
	Mormugao				
18	(M Cl) WARD NO.-0001	3659	203	7	3449
19	(M Cl) WARD NO.-0002	2518	11	23	2484
20	(M Cl) WARD NO.-0003	3071	17	4	3050
21	(M Cl) WARD NO.-0004	3852	108	48	3696
22	(M Cl) WARD NO.-0005	4462	113	27	4322
23	(M Cl) WARD NO.-0006	4059	78	10	3971
24	(M Cl) WARD NO.-0007	3428	2	0	3426
25	(M Cl) WARD NO.-0008	4791	45	6	4740
26	(M Cl) WARD NO.-0009	5507	123	64	5320
27	(M Cl) WARD NO.-0010	4387	36	10	4341
28	(M Cl) WARD NO.-0011	1954	35	0	1919
29	(M Cl) WARD NO.-0012	3897	10	0	3887
30	(M Cl) WARD NO.-0013	4175	31	14	4130
31	(M Cl) WARD NO.-0014	4103	36	15	4052
32	(M Cl) WARD NO.-0015	5661	325	28	5308

Sr. No	Name of Settlements	Total Population	Schedule Caste Population	Schedule Tribe Population	General Population
33	(M Cl) WARD NO.-0016	5171	55	35	5081
34	(M Cl) WARD NO.-0017	6061	73	53	5935
35	(M Cl) WARD NO.-0018	11104	661	57	10386
36	(M Cl) WARD NO.-0019	4517	120	9	4388
37	(M Cl) WARD NO.-0020	8016	79	70	7867
38	Chicalim (CT)	6933	76	234	6623
39	Sancoale (CT)	21923	114	597	21212
40	Cortalim (CT)	9080	37	2255	6788
	Subtotal (Y)	144,062	2508	4330	137224
	Total (X+Y)	286288	6082	16676	263530

Source: Primary Census Abstract, 2011

3.13.2. Literacy Rate

The details of literate and illiterate population are represented in Table 4.28. Out of the total population in the study area, about 81.50% are literate while about 18.50% are illiterate. The male and female literacy rates are 53.99% and 46.01% respectively.

3.13.3. Occupational Profile

The details on occupational profile within the study area are given in Table 21 and shown in . About 41.59% of the total population is engaged in economically productive activities. The remaining 54.41% are designated as “non-working” population. Among the working population, about 88.91% are main workers while 11.09% are marginal workers.

Table 3.23: Literacy levels in study area villages

Sr. No	Name of Settlements	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
	District North Goa Sub district Tiswadi							
1	Batim	1489	1218	633	585	271	106	165
2	Curca	2518	1952	1014	938	566	218	348
3	Siridao	2417	1786	929	857	631	250	381
4	Panaji (M Corp. + OG)	70991	60071	31090	28981	10920	4898	6022
5	Cujira (OG)	1229	1033	516	517	196	85	111
6	Taleigao (OG)	24201	19755	10441	9314	4446	1961	2485
7	Durgawadi (OG)	1610	1345	710	635	265	120	145
8	Murda (CT)	7517	6117	3066	3051	1400	633	767
9	Calapor (CT)	14077	11628	6043	5585	2449	1075	1374
10	Bambolim (CT)	6885	5971	4362	1609	914	450	464
11	Mercurim (CT)	4970	3982	1940	2042	988	389	599
12	Goa Velha (CT)	4322	3473	1779	1694	849	350	499
	Subtotal (X)	142226	118331	62523	55808	23895	10535	13360

Sr. No	Name of Settlements	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
	District South Goa Sub district Mormugao							
13	Dabolim	6027	4739	2550	2189	1288	592	696
14	Sao Jacinto Island	195	171	92	79	24	12	12
15	Pale	1990	1537	834	703	453	176	277
16	Issorcim	841	718	383	335	123	51	72
17	Chicolna	2680	2117	1127	990	563	223	340
18	(M Cl) WARD NO.-0001	3659	3433	2379	1054	226	104	122
19	(M Cl) WARD NO.-0002	2518	2136	1127	1009	382	166	216
20	(M Cl) WARD NO.-0003	3071	2547	1355	1192	524	211	313
21	(M Cl) WARD NO.-0004	3852	3228	1828	1400	624	288	336
22	(M Cl) WARD NO.-0005	4462	3488	1949	1539	974	407	567
23	(M Cl) WARD NO.-0006	4059	3361	1715	1646	698	324	374
24	(M Cl) WARD NO.-0007	3428	2348	1348	1000	1080	466	614
25	(M Cl) WARD NO.-0008	4791	3384	1893	1491	1407	587	820
26	(M Cl) WARD NO.-0009	5507	4468	2448	2020	1039	448	591
27	(M Cl) WARD NO.-0010	4387	3688	1956	1732	699	284	415

Sr. No	Name of Settlements	Total Population	Population Literate	Male Literate	Female Literate	Population Illiterate	Male Illiterate	Female Illiterate
28	(M Cl) WARD NO.-0011	1954	1708	882	826	246	106	140
29	(M Cl) WARD NO.-0012	3897	2841	1565	1276	1056	447	609
30	(M Cl) WARD NO.-0013	4175	3453	1894	1559	722	303	419
31	(M Cl) WARD NO.-0014	4103	3501	1839	1662	602	260	342
32	(M Cl) WARD NO.-0015	5661	3901	2290	1611	1760	768	992
33	(M Cl) WARD NO.-0016	5171	4191	2249	1942	980	462	518
34	(M Cl) WARD NO.-0017	6061	4736	2558	2178	1325	592	733
35	(M Cl) WARD NO.-0018	11104	9056	4755	4301	2048	999	1049
36	(M Cl) WARD NO.-0019	4517	3669	1948	1721	848	364	484
37	(M Cl) WARD NO.-0020	8016	6931	3570	3361	1085	499	586
38	Chicalim (CT)	6933	5886	3478	2408	1047	443	604
39	Sancoale (CT)	21923	16656	9429	7227	5267	2228	3039
40	Cortalim (CT)	9080	7111	4013	3098	1969	783	1186
	Subtotal (Y)	144062	115003	63454	51549	29059	12593	16466
	Total (A+B)	286288	233334	125977	107357	52954	23128	29826

Source: Primary Census Abstract, 2011

Table 3.24: Occupational profile of study area

S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
	District North Goa													
	Sub district Tiswadi (X)													
1	Batim	1489	422	347	42	3	26	276	75	6	6	5	58	1067
2	Curca	2518	925	877	58	9	6	804	48	3	6	1	38	1593
3	Siridao	2417	867	676	69	13	15	579	191	14	11	3	163	1550
4	Panaji	70991	30220	27709	206	77	299	27127	2511	57	43	125	2286	40771
5	Cujira	1229	481	409	5	2	7	395	72	2	2	3	65	748
6	Taleigao	24201	10437	9582	67	36	111	9368	855	19	22	63	751	13764
7	Durgawadi	1610	645	597	3	0	4	590	48	1	0	0	47	965
8	Murda (CT)	7517	3015	2626	14	14	74	2524	389	8	3	21	357	4502
9	Calapor (CT)	14077	5743	5239	46	28	87	5078	504	10	9	24	461	8334
10	Bambolim (CT)	6885	4429	4252	33	4	8	4207	177	2	14	3	158	2456
11	Mercurim (CT)	4970	1718	1399	91	34	42	1232	319	44	122	7	146	3252
12	Goa Velha (CT)	4322	1771	1506	29	21	137	1319	265	12	19	2	232	2551
	Subtotal (X)	142226	60673	55219	663	241	816	53499	5454	178	257	257	4762	81553
	District South Goa													

S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
	Sub district Mormugao (Y)													
13	Dabolim	6027	2563	2434	174	19	34	2207	129	15	21	4	89	3464
14	Sao Jacinto Island	195	54	52	6	0	0	46	2	0	1	1	0	141
15	Pale	1990	701	585	46	14	11	514	116	3	64	1	48	1289
16	Issorcim	841	359	354	28	0	16	310	5	0	0	0	5	482
17	Chicolna	2680	1032	937	68	5	41	823	95	13	5	4	73	1648
18	WARD NO.-0001	3659	2176	1808	232	5	0	1570	369	11	1	1	356	1483
19	WARD NO.-0002	2518	952	875	4	3	21	847	77	0	1	10	66	1566
20	WARD NO.-0003	3071	1002	889	4	4	14	867	113	2	0	8	103	2069
21	WARD NO.-0004	3852	1347	1264	11	0	14	1239	83	1	0	1	81	2505
22	WARD NO.-0005	4462	1729	1622	15	27	10	1570	107	7	5	4	91	2733
23	WARD NO.-0006	4059	1565	1364	5	2	41	1316	201	1	1	5	194	2494
24	WARD NO.-0007	3428	1472	1355	6	3	4	1342	117	3	0	2	112	1956
25	WARD NO.-0008	4791	1861	1634	11	21	38	1564	227	6	6	6	209	2930
26	WARD NO.-0009	5507	2052	1859	12	3	20	1824	193	5	2	11	175	3455
27	WARD NO.-0010	4387	1634	1407	4	6	23	1374	227	6	3	7	211	2753
28	WARD NO.-0011	1954	801	782	9	0	4	769	19	0	0	0	19	1153
29	WARD NO.-0012	3897	1554	1373	11	2	17	1343	181	5	0	0	176	2343

S. No	Name of Settlements	Total Population	Total Working Population	Main Workers	Main Workers Cultivators	Main Agricultural Labour	Main Household Industry	Main Other Occupation	Marginal Workers	Marginal Cultivators	Marginal Agricultural Labour	Marginal Household Industry	Marginal Other Occupation	Non Workers
30	WARD NO.-0013	4175	1996	1576	15	6	10	1545	420	4	2	72	342	2179
31	WARD NO.-0014	4103	1543	1413	5	7	7	1394	130	6	4	2	118	2560
32	WARD NO.-0015	5661	2139	1955	12	4	20	1918	185	0	0	2	183	3522
33	WARD NO.-0016	5171	2071	1514	5	5	13	1491	557	7	2	1	547	3103
34	WARD NO.-0017	6061	2195	1663	10	1	11	1641	532	3	3	15	511	3866
35	WARD NO.-0018	11104	4121	3579	19	6	29	3525	542	7	2	2	531	6983
36	WARD NO.-0019	4517	1617	1457	13	4	19	1421	160	2	1	8	149	2900
37	WARD NO.-0020	8016	3102	2821	12	5	28	2776	281	12	0	1	268	4914
38	Chicalim (CT)	6933	3438	3201	20	5	35	3141	237	13	16	6	202	3495
39	Sancoale (CT)	21923	9310	7795	41	36	53	7665	1515	38	66	48	1363	12613
40	Cortalim (CT)	9080	3978	3045	21	55	14	2960	928	21	75	6	826	5102
	Subtotal (Y)	144062	58364	50613	819	248	547	49002	7748	191	281	228	7048	85701
	Total (X+Y)	286288	119037	105832	1482	489	1363	102501	13202	369	538	485	11810	167254

Source: Primary Census Abstract, 2011

3.13.4. Infrastructure

The area is more urban in nature with well-developed social, physical and industrial infrastructure and virtual connectivity with basic amenities. Tourism is one of the major income sources of Goa state. It has an international airport that is in line with its importance as a globally-recognised leisure destination. It also has significant port infrastructure.

3.13.5. Education

The study area has several educational institutes. Out of the total population in the study area, about 81.50% are literates (Census, 2011). Several primary, secondary schools and colleges were located within study area. Goa University, National Institute of Oceanography (NIO), National Centre for Antarctic and Ocean Research (NCAOR), Institute of Maritime Studies etc. are some of the prominent institutes in the study area.

3.13.6. Healthcare facilities

Healthcare facilities are the most important parameter for any area and it is one of the primary requirements of people. The study area is equipped with excellent medical services with the joint efforts of government and private hospitals. The amenities used in these hospitals are all modern and latest technology based and the treatment procedures are at par with the leading countries. There are several government hospitals, primary health care centres and community health centres which altogether takes care of the health care requirements in the study area. Goa Medical College, MMPT Hospital, Manipal Hospital, SMRC, Rajagiri Victor Hospital etc are some of the well occupied hospitals in the study area. Apart from this there are plenty of private reputed hospitals and Nursing Homes which also take part in treating the people of the study area. They have modern treatment facilities along with assistance of high-end doctors which make treatment in these hospitals extremely good.

3.13.7. Transport

The study area has a fairly well developed network of transport and communication system. It is served by railway, roadways, inland waterways and airways as well as by post and telegraph service, telephone, telex, exchanges etc. It has a very good natural harbour at Mormugao. Zuari river provides inland waterways and are extensively used particularly to transport minerals to the port. With the objective of providing safe, regular, reliable and

comfortable road transport to the traveling public and to connect interior remote areas with the urban centers, Kadamba Transport Corporation (KTC), a wholly owned company of the Government of Goa. Beside buses there are taxis, motorcycle on hire and auto rickshaws. The three national highways passing through the study are the Panvel-Kochi-Kanyakumari Highway (NH 66), Cortalim - Murmagao (NH 366) and Ponda- Verna- Vasco da Gama highway (NH 566). Regarding railway transport, there is a broad gauge line in South Goa extending from Mormugao Harbour. Also the Goa International Airport is situated within study area at Dabolim.

3.13.8. Tourism

Goa is today known nationally and internationally and occupies a high place on tourist map of the world. Old heritage monuments, Archaeological Sites, Forts, temples are tourist attraction spots. Apart from its historicity is also renowned for its scenic beauty. Indeed, it is a tiny paradise with some of the loveliest beaches. The old heritage monuments of Our Lady of Rosary, Mormugao fort, Aguada Fort, beaches like Baina beach, Grand Mother's Hole Beach, Bogmalo beach, Velsao Beach are situated in the study area.

Grande Island Archipelago

The Grande Island Archipelago, located between latitude 150 21'N and longitude 730 46'E comprising two coastal islands (Grande Island and St. George Island, Figure 3.22) separated by a short, narrow channel is roughly 3 km off the shore of Vasco, Goa. It is one of the few coastal islands on the west coast of peninsular India where coral reefs have been documented. Coral reefs are considered as biodiversity "Hotspots" as they host vast number of biological species and provide numerous ecological and economic benefits to mankind. The waters around the islands house patches of coral growth and small expanses of fringing reef, which give way to a sandy sea bed. The reefs around these islands consist primarily of table coral and encrusting coral, with a few sandy patches supporting abundant sea whip growth as well.

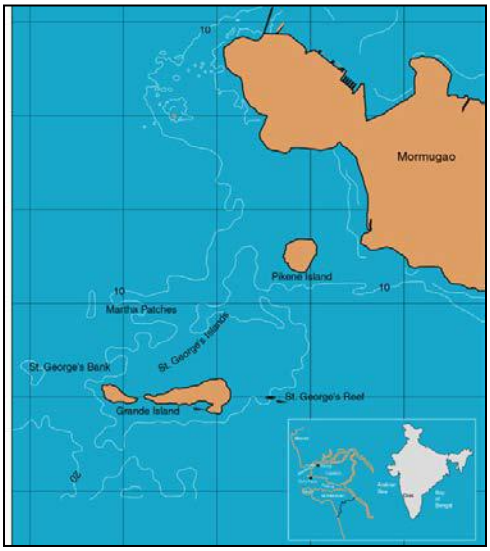


Figure 3.21: Grande Island Archipelago

Ecological studies conducted at this site estimated the coral cover around the island at 31%. According to the recently published scientific reports the sub tidal areas around the Grande island is rich in Corals (21 species), sponges (9 species), reef fishes (75 species), seaweeds (15 species) and associated flora and fauna (Hussain et al., 2015; Sreekanth et al 2015; Manikandan et al 2016). Moreover coral reefs are universally recognized as breeding ground of many commercially important fishes, crustaceans, molluscs and other invertebrate species.

The presence of corals, reef fishes and coral associated biodiversity made Grande Island as preferred tourist spot especially for sport fishing, underwater SCUBA diving, snorkelling, which is polluting the coral environment and adding additional stress on the sensitive coral reef ecosystem. Consequently, any additional anthropogenic stress may be avoided in the vicinity of the island.

Zuari Estuary

The Zuari estuary on the west coast of India is a dynamic tropical estuary. It is formed by Zuari River. River Zuari originates from the Dighi Ghat on the Sahyadri hills. . It is 5.5 km wide at the mouth, while upstream it narrows down to less than 0.5 km. The 10-km stretch upstream from the mouth of the Zuari estuary, known as the Mormugao Bay, is approximately 5 km wide.

It is fed by the monsoon precipitation and receives discharge from a catchment area of about 550 km2. The Zuari and along with Mandovi Rivers form an estuarine system. They are the backbone of Goa's agricultural industry. The two rivers are connected by a man made canal known as Cumbarjua Canal of about 17 km length and 0.2 to 0.5 km in width and about 14 and 11km away respectively from the mouths of Mandovi and Zuari (Zuari Estuary Figure 3.23)

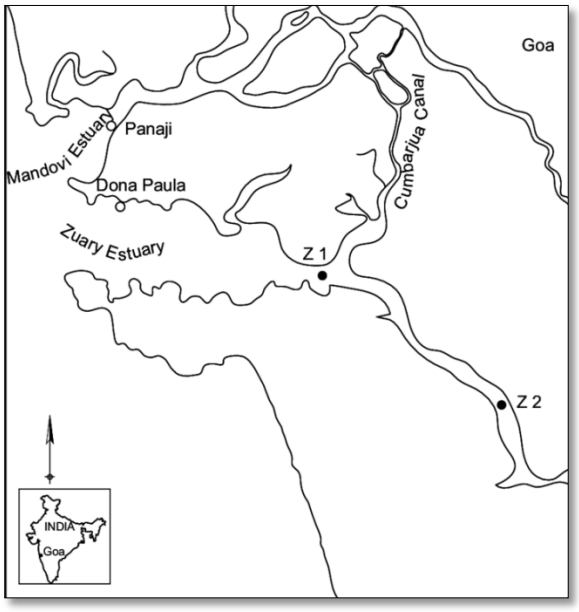


Figure 3.22: Zuari Estuary

Mangrove vegetation at present is seen all along north of the river bank which makes the Zuari river region biologically productive. The Zuari estuary sustains a rich biodiversity with fisheries and edible organisms such as prawns, fishes and clams are exploited from the region. In a recent study, conducted between October 2013 and September 2014, the Indian Council of Agricultural Research (ICAR), Old Goa (Goa) identified a total of 186 aquatic species (150 finfish and 36 shell fish) in the mouth of Zuari Estuary. The 150 finfish species comprised of 65 pelagic and 85 demersal fishes. The shellfish fauna comprised of 17 crustacean and 19 molluscs species. It was evidently reported that the fish and shellfish diversity along the estuarine ecosystem of Zuari mouth is rich and accounts for a significant quantity of Goa’s marine and brackish water fish production.

However, the loss of these precious fishery resources and their habitats due to various causes like pollution, coastal development and intense illegal fishing necessitates their replenishment by some strategic approaches.

Sancoale Bay

This area has good mangrove vegetation and a vast expanse of mudflat exposed during the low tide. There is presence of species with conservation importance such as windowpane oyster and other commercially important molluscs such as clams, oyster, windowpane oyster and cephalopods etc. Chikalim- Sancoale bay is considered an important location for intertidal marine biodiversity. Chikalim and Nauxim Bays in the Zuari estuary is home for windowpane oyster which is a schedule species. There is scarce data about the total quantity of shellfish collected from each of the habitats seasonally.

Caboraj - Dona Paula- Siridao Rocky intertidal zone

The rocky intertidal and subtidal habitats between Caboraj- Dona Paula- Siridao have high seaweed abundance and diversity. Over 90 seaweed species are reported earlier from the area with higher biomass. Increase in sedimentation during the dredging may pose significant harm to the distribution of seaweeds. Generally the destruction of seaweed also results in great loss in biodiversity and thus results in resource depletion.

Dr. Salim Ali Bird Sanctuary

Salim Ali Bird Sanctuary is a mangrove habitat which is declared as a bird sanctuary and located on western tip of the Island of Chorao along the river Mandovi, Goa. The area of the sanctuary is 1.78 sq.km (440 acres). Sanctuary was established in 1988 in order to protect unique habitat for birds and is located just approximately 4 km away from Capital City Panaji.

Several species of birds have been recorded and the common species include the striated heron and western reef heron. Other species that have been recorded include the little bittern, black bittern, red knot, jack snipe and pied avocet. The sanctuary is also host to mudskippers, fiddler crabs and other mangrove habitat specialists.

4. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

This chapter deals with the expected impacts and the respective mitigation measures of the project on the environment during different stages. It indicates the levels up to which the proposed infrastructure development will benefit the project site by preventing or minimizing adverse environmental impacts.

The activities involved in the proposed expansion and modernization of infrastructure include the construction of jetties and berths and deepening of berths. The increased capacity of the port due to the proposed development will increase the number of ship calls to the port. The proposed development will comprise of construction activities including piling; RCC works and capital dredging. A total marine reclamation work of about 85195m^2 is involved. A total dredged quantity of about 15,05,660 m^3 is involved.

4.1. Impact Due to Project Location

The proposed project includes the modernization and expansion of existing port by the addition of four more jetties, two more berths and the deepening of 3 existing berths. The existing Port has been accorded environmental clearance and the proposed project development activity is planned within the existing port. Since the proposed development is within an operational port, there will not be any major impacts on the environmental components due to the location of the proposed development.

Moreover, proposed fishing harbor and passenger jetty projects are beneficial for boosting local economy.

4.2. Land Environment

4.2.1. Impacts on Land during the Construction Phase

The proposed project activities are planned within existing port area; hence no land acquisition is required. All the activities are within the Mormugao Port limits and hence, no major impact is anticipated on land use.

Construction related activities such as clearing the site, excavation, the generation of construction waste etc affect the land environment directly. Clearing the site and excavation coupled with removal of vegetation triggers soil erosion and loss of top soil. Soil erosion can in turn trigger an increase in the turbidity levels in the coastal water. However, majority of

project area is proposed on reclaimed land, hence there are no chances of soil erosion due to excavation.

Soil contamination may take place due to solid wastes generated during the construction phase. The solid and hazardous wastes, if generated from ships and from port operations may contaminate land, if not disposed properly.

Mitigation Measures

The construction waste generated shall be partly used for land filling and restoration of the project site. Balance material will be disposed as per the guidance of Mormugao Municipal Authority at designated sites. The Hazardous Solid Waste shall be treated as per the Hazardous waste management Rules 2016.

4.2.2. Impacts on Land during the Operation Phase

The only land parcel involved in this proposal is back up area of coastal and general cargo berth. Development of fishing harbor, passenger jetty and liquid berth will be on reclaimed land. Handling of any liquid or bulk cargo is not envisaged from coastal cargo berth. Hence, contamination of land through leaching is not possible.

Mitigation Measures

Adequate measures shall be taken to ensure that all waste generated at the site is collected and disposed off as per the requirements stipulated by Mormugao Municipal Authority.

Hazardous waste likely to be generated from proposed facilities is the wastes such as oil and grease from machinery and equipment which will be disposed off as per Hazardous waste (management) Rules 2016.

4.3. Fresh Water Environment

4.3.1. Impacts on Fresh Water during the Construction Phase

No fresh water surface bodies are present at the proposed project site. Moreover, construction activities are confined to marine areas. Hence, there will be no significant impacts on surface water. The average no. of construction labourers likely to be deployed for the execution of the proposed project will be about 70. No labour camps are envisaged at the project site as the labours will be local residents and the existing sanitation facilities of Mormugao Port will be

sufficient. The total water requirement for domestic purposes during construction phase has been estimated as 3.5 m^3/day and the quantity of domestic sewage likely to be generated during construction phase will be about 3 m^3/day.

The sewage can have an adverse impact on the DO levels of the receiving body, if disposed without proper treatment. The existing sewage handling facilities (STPs) in operation at Mormugao Port, can handle the additional inputs due to the proposed modernization activities in the Port.

Apart from the domestic water requirements, fresh water will be required for construction purpose also. The total fresh water requirement during construction phase has been estimated as 20 m^3/day, out of which 16.5 m^3/day is the average requirement for construction activity.

The water demand will be met from existing sources of Mormugao port (PWD Goa)

Mitigation measures

The sewage generated in construction of new facility shall be collected in collection tanks and transported through tankers to existing port sewage treatment plant.

4.3.2. Impacts during the Operation Phase

Fresh water requirement for operation phase has been estimated at 142 m^3/day. The water will be obtained from Public Works Department (PWD), Goa

Mitigation measures

The solid and liquid waste generated at the site will be treated and disposed off as prescribed by the SPCB..

4.4. Marine Environment (Coastal Hydrology/Bottom Contamination)

4.4.1. Impacts on Marine Environment during the Construction Phase

Impacts on the marine ecology during the construction phase can be due to modifications in the hydrodynamic characteristics of the area, impacts on water and sediment qualities and impacts on fishing activities. Sediment samples analyzed from the project area did not show the presence of any appreciable levels of contamination and hence may not pose any problems of contamination. Dredged spoil will be disposed at pre-designated site of Mormugao Port Trust.

Pile driving, deposition of rubble, dredging, sand compaction, reclamation and other construction activities increase the turbidity levels in the coastal water which is a short term impact. The turbidity level returns to the pre-project level after the completion of construction activities.

Construction activities will pose impact on the biota in the pile-footprint areas of berth and reclamation area. Benthic population in Vasco bay region was observed to be 52 to 140 nos./m^2. Project site does not sustain seaweeds, mangroves or corals. Hence, no further impacts on these sensitive marine habitats are envisaged due to reclamation. Primary production in this region is moderate and reduction in productivity will be confined to a small segment of the marine zone due to construction activities.

Disturbance from construction activities may cause displacement of fishery resources and other mobile bottom biota. Dredging removes bottom biota and dumping of dredged material covers bottom habitat, both of which may reduce fishery resources. Settlement of re-suspended sediments on fragile marine fauna and flora damages the ecosystem particularly coral reefs. However, corals near Grande Island are almost 7 km away from construction site. Sediments plume during dredging is not expected to travel till Grande Island. Hence, there will be no major impact of dredging on corals.

Impacts on current and sediment transport due to new offshore constructions are discussed separately in Chapter 6 – Additional Studies. Hydrodynamic modeling for these aspects have been carried out by CWPRS, Pune.

Mitigation measures

Construction activity shall be completed within designated period. Dredging must be confined to project area and must be completed within stipulated time period.

Hazardous material such as waste oil, empty paint cans, used welding buts shall not be dumped into marine waters.

4.4.2. Impacts during the Operation Phase

Contamination of sediment is not envisaged once construction is complete. Only clean cargo such as break bulk and containers will be handled from coastal berth.

The discharge from ships that could be sources of water pollution include bilge water, ballast water, oily wastes, sewage, garbage and other residues from the ship. Spills of oil, fuel, etc. can also be the source of pollution. Other solid and liquid wastes will also be generated by the end users including ships' crews.

In case of accidental spills the existing oil spill contingency plan of the MPT will be put into action. The spill will be contained by deploying oil booms and the trapped oil will be skimmed for pumping and collection. Also dispersant chemicals will be used to treat the spill. The collected oil will be stored temporarily and disposed through authorized contractors. Periodical clean-up of floating wastes will also be undertaken when necessary, for maintaining the desired Port water quality.

The CWPRS, Pune has been designated to carry out an Oil spill modelling study in the project area.

Operation of fishing harbor will poses tremendous impact on marine environment, if not managed properly. Discharge of waste oil for fishing trawlers, unsegregated fish offal and untreated sewage from fishing harbor will turn the area into filthy place.

Mitigation Measures

Oily and other contaminated discharge from the dredgers or work boats should be prevented from entering marine waters. The capital as well as maintenance dredging should be confined within the project site and the activity should be terminated as per planned schedule.

A schedule for dredging shall be prepared and a list of DO(s) and DO NOT(s) shall be circulated among the personnel involved in the construction activities.

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 temporarily suspended until baseline is attained.

Discharge of waste wastes into sea should be prohibited. Spill control measures shall be adopted while bunkering dredgers and fishing boats, etc. Any effluent generating from fishing harbor, auction hall, ice storage etc. shall be treated in ETP.

Post dredging monitoring program should be carried out to assess the effect of dredging and disposal on marine ecology.

Environmental Monitoring Program comprising of monitoring of marine water quality, marine sediment quality and marine ecology should be taken up a week prior to the commencement of dredging and continued at periodic intervals throughout dredging period

An adequate drainage system should be provided at the site with separate collection streams to segregate the storm run-off from roads, open areas, material storage areas, vehicle wash water and other wastewater streams. No construction shall be permitted during rainy days or extreme climatic conditions. Suitable measures will also be taken to prevent the washing away of construction materials into the drainage system. Contaminated storm water will be collected and conveyed to sedimentation tank for removing grit.

4.5. Biological Environment (Coastal and Marine Ecology)

4.5.1. Impacts on Marine Ecology during the Construction Phase

The impacts on terrestrial environment due to the proposed activities can be considered negligible, whereas, there will be more significant impacts on the marine environment.

Biomass of phytoplankton depends mainly on the availability of light in nutrient rich waters. Dredging and disposal of dredged spoils leads to increased turbidity and consequent reduction of light penetration till turbidity levels are high. This may affect primary productivity and plankton biomass. However, turbidity due to dredging and dumping will be observed only in a localized area and only for a very short duration. Hence these impacts are not expected to be significant in nature.

A temporary and localized reduction in phytoplankton population is unlikely to produce any adverse impact on zooplankton. However, localized and marginal changes in community structures and population alterations are expected. Such changes are temporary and irrelevant to the overall zooplankton population of the coastal system off Zuari Estuary.

During all dredging operations, the removal of material from the sea bed also removes the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in complete removal of animals from the excavation site. In areas to be covered under maintenance dredging well-developed benthic communities are not expected to occur in or around the area. Since, the significant macro-and meio-fauna

is not developed in the area, hence dredging is not expected to lead to significant adverse impacts.

Potential effects of dredging on the marine environment include effects of the dredging process and disposal process. During the dredging process effects may arise due to the excavation of sediments at the bed, loss material during transport to the surface, overflow from the dredger whilst loading and loss of material from the dredger and/or pipelines during transport. We must also consider the environmental effects that may occur as a result of the physical changes to bathymetry and hydrodynamic processes that dredging makes. Light attenuation by suspended sediments affects the amount of light available to seagrass plants, coral reef and several marine organisms.

Dredging and associated vessel movement are a potential threat to the marine mammals especially the dolphins, which may be harmed due to collision, propeller action and underwater rope, wires and anchorage material.

Mitigation Measures

Dredging and associated activities should be avoided during the notified fish breeding season (June-July) which is considered as egg laying and larval recruitment season. The primary focus of environmentally friendly developments in the dredging has been on a reduction of turbidity levels associated with the dredging process. The developments have mostly focused on modifications to dredge cutter heads to significantly reduce the generation of turbidity at the bed. However there have also been developments related to hopper dredges operating in offshore areas, and these have mostly stemmed from:

1) Need to reduce turbidity levels to address regulatory agency concerns and simple visual perception of impacts

2) The trend towards much larger hopper dredges to serve very large land reclamation projects.

The type of dredging to be done and the type of dredger to be deployed are to be decided on the basis of the soil profile. The two types of dredger available are listed below.

Trailing Suction Dredger

This type of dredger is suitable for dredging loose sand and clay which is predominantly seen in the area to be dredged. A trailing suction hopper dredger (TSHD) trails its suction pipe when working, and loads the dredge spoil into one or more hoppers in the vessel. When the hoppers are full, the TSHD sails to a disposal area and either dumps the material through doors in the hull or pumps the material out of the hoppers. Some dredges are equipped with automatic offloading using drag buckets and conveyors.

Cutter Suction Dredger

The Cutter section dredger is used when presence of the hard soil in the profile is encountered. The cutter suction dredger is a stationary dredger equipped with a cutter device (cutter head), which excavate the soil before it is sucked up by the flow of the dredge pump(s). During operation the dredger moves around a spud pole by pulling and slacking on the two fore sideline wires. This type of dredger is capable to dredge all kind of material and is accurate due to their movement around the spud. The spoil is mostly hydraulically transported via pipeline.

Most environmentally friendly developments related to CSDs are associated with modifications to the cutter head, largely driven by projects to remove contaminated sediments from rivers and harbors. As one example, a low turbidity cutter head have been designed, to be mounted on cutter suction dredges to accurately remove thin layers of silt, dredge material at in situ density, work in shallow areas, and reduce mechanical disturbance of the bed, thus reducing turbidity.

4.5.2. Impacts on Marine Ecology during the Operation Phase

Only major impact on marine ecology is expected from accidental oil spills at liquid cargo berth. Oil destroys the water repellency of a bird's feathers, thus exposing these creatures to the harsh elements. Without the ability to repel water and insulate from the cold water, birds may die from hypothermia.

Many birds also ingest oil when they try to clean themselves, which can poison them. Fish, shellfish and marine mammals may not be exposed immediately, but can come into contact with oil if it is mixed into the water column. When exposed to oil, adult fish may experience

reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion, and reproduction impairment. Oil also adversely affects eggs and larval survival.

Mitigation Measures

Proposed development is within Mormugao Port limit. MPT has already developed oil spill contingency plan and same will be adopted during accidental spill at proposed liquid cargo berth.

4.6. Air Environment

4.6.1. Impacts on Air during the Construction Phase

Emissions from construction equipment, work vessels, trucks and other vehicles used in construction work could be a source of air pollution. Dust from construction activities is also a possible source of air pollution.

Transportation of material may lead to rise in the fugitive dust and gaseous emissions during filling operations. This will be restricted to the construction area and will manifest only during the ongoing works.

Transportation of reclamation and construction material will lead to rise in the traffic during construction phase. Hence, transportation activity will increase fugitive dust and gaseous emissions in the area.

The major pollutant in the construction phase is Suspended Particulate Matter (SPM) being air-borne due to various construction activities. The vehicular movement generates pollutants such as NOx, CO and HC. But, the vehicular pollution is not expected to lead to any major impacts. The impact on air environment during construction phase is expected to be local and reversible. The combustion of diesel in construction equipment could be one of the possible sources of incremental air pollution during the construction phase.

Mitigation Measures

Regular water sprinkling can help in containing the fugitive emissions. For control of the airborne particles of cement enclosed storage facility shall be provided & material shall be covered with tarpaulin during the transportation.

Only vehicles having PUC shall be allowed & well equipped handling & transportation facilities shall be provided through out the construction phase.

For control of emission from DG set, stack of adequate height shall be provided to minimize the impacts of emission. The residual impacts of emission from the stack would not be significant to cause any considerable impacts on air. The adverse impacts will be almost eliminated or minimized to the lowest extent of damage by implementing the proper mitigation measures.

4.6.2. Impacts on Air during the Operation Phase

The proposed project activities do not involve handling of bulk cargo. Hence, pollution from fugitive dust emission is not expected. The vehicular traffic on roads will increase with the additional facilities which in turn will increase the air pollution

Mitigation measures

The D.G. sets, engines and auxiliaries must be provided with filters and adequate height stacks. All roads shall be paved and adequate green cover shall be developed near the proposed facilities. All boats shall be maintained and repaired on regular intervals.

4.7. Noise and Vibration

4.7.1. Impacts on Noise during the Construction Phase

Construction activities may create a problem of noise and vibration generated by construction equipment, truck traffic, work vessels and other similar sources. The noise levels generated by construction equipment are given in Table 4.1.

Table 4.1: Noise levels expected to be generated from construction equipment

Equipment	Sound level (dBA)
Floating pontoon with mixer machine and crane	70
Winch machine	80
Transit mixer	75
Dumpers	75
Generators	85
Batching plant	90

Air compressors	90
Pile drivers	115

Mitigation Measures

Transmission of noise and vibration are limited by the distance from their sources. Noise could be considerably reduced by adoption of low noise equipment or installation of sound insulation barriers. Green belt can be a good barrier to noise as well as dust emissions.

4.7.2. Impacts on Noise during the Operation Phase

During project operation phase also, the major source of noise could be due to operation of various equipment. Fitting of exhaust mufflers and intake mufflers could reduce the noise from equipment. It is very useful for reducing the low frequency noise levels.

Mitigation Measures

Proper lubrication, muffling and modernization of equipment shall be done to reduce the noise, D.G. Set with acoustic enclosure shall be provided. It is recommended that workers operating various equipment during project construction and operation phases are provided with ear plugs.

4.8. Solid Waste Generation

4.8.1. Solid Waste Generation during the Construction Phase

No labour camps are required for the project and hence the quantity of domestic solid waste generated will be very limited.

The municipal waste generated during project construction phase shall be of the order of only 0.03 t/day. The dredged spoils shall be used in the extent possible for reclamation and unsuitable material will be disposed off at the designated location.

Mitigation Measures

Municipal solid waste generated will be disposed off through the Mormugao Municipality Authority. The solid waste generated during construction phase will consist of biodegradable waste such as food waste and non-biodegradable waste such as packaging material, plastic, metal items, etc. All the recyclable items shall be collected and sold to authorized recyclers.

The construction waste generated shall be used partly for land filling and restoration of the project site. Balance material will be disposed as per the guidance of the Mormugao Municipal Authority at designated road construction sites.

4.8.2. Solid Waste Generation during the Operation Phase

During operation phase maximum solid waste will be generated from fishing harbor and general/coastal cargo berth. The following solid waste management plan is recommended for the proposed fishing harbour development.

Biodegradable Waste from Fishing Harbour

Collection: Adequate containers will be strategically placed within the harbour complex for collecting the litter and offal. Separate (colour coded) air tight PVC containers will be used to facilitate the segregation of waste into non- biodegradable waste, biodegradable organic waste.

Recycle: The organic fish waste which is collected from the 'air tight waste collection bins' kept at the wharf and auction hall areas are brought to 'organic waste composter unit' as well as it can be sold out to fish meal producers.

Fish/ organic wastes collected from the waste collection bins are brought to the organic waste converter platform for composting. Waste from the platform is shredded and then transferred to a organic waste composter machine where the waste is mixed with a suitable absorbent like paper or sawdust. This is followed by addition of bacterial inoculums inside the converter for organic waste digestion. The raw digested material is left for curing for about 15 days to get good quality compost. The compost can be used as manure for the greeneries in and around the Port.

Non-biodegradable wastes from Coastal / General Cargo Berth

The non-degradable waste will be first segregated so as to remove the material that can be recycled. Metal items shall be collected and sold to scrap dealers. Tyres can be turned into fenders. The plastic materials (~30 kg/day) are to be collected and periodically handed over to authorized scrap dealers. Hazardous waste such as oily rags, empty drums, waste oil shall be disposed to recyclers authorized by Goa Pollution Control Board.

4.9. Socio-Cultural Impacts

4.9.1. Social Impacts during the Construction Phase

In the construction stage about 70 construction labours from the nearby localities are likely to be deployed and hence no labour camps are proposed to be constructed at the project site.

The issues pertaining to resettlement and rehabilitation are not envisaged in this project, as there is no land acquisition involved, as the proposed development is within the existing port.

4.9.2. Social Impacts during the Operation Phase

The major socio-economic impact of the proposed development is that it will trigger economic development. When compared to other transportation systems, water transport is environment friendly, as it is less polluting, with lower energy consumption.

Port expansion activities will increase employment opportunities. The construction of fishing jetty with the ancillary facilities will be a boon to the local fisherman community. The berths for liquid bulk and multipurpose cargoes will result in increased trade (both exports and imports). The passenger jetty will also be a boon to the local residents and it enhances water transport and tourism.

5. ENVIRONMENT MONITORING PLAN

This section of the report describes the time schedule and monitoring program for compliance with the recommended mitigation measures. Methods have been designed in such a way that it is possible for the project proponent to demonstrate that the mitigation measures are effectively implemented during construction and operation phases. The proposed monitoring plan during the construction and operation phases is presented in Table 5.1.

Table 5.1: Monitoring Schedule during Construction and Operation Phase

Aspects	Parameters to be monitored	Frequency of Monitoring	Locations	Compliance
Air Quality	PM10, PM2.5, SO2, NO2, CO	Twice in a week during entire construction period	Project Site	NAAQ Standards, 2009
Noise Levels	Day and night noise levels	Once in month for 24 hrs	Project Site	CPCB Standards
Water Quality	pH, Temp, Salinity, TDS, TSS, DO, BOD, Hardness, Alkalinity, Chlorides, Turbidity, Conductivity, Oil and Grease, Heavy Metals	Once in a month during entire construction period	MPT Office	IS10500: 2012
Soil Quality	pH, Electrical Conductivity, Organic Matter, Organic Carbon, Phosphorous (as PO4-3), Total Kjehldal Nitrogen, Potassium (as K), Sodium (as Na), Texture, Sand, Clay,	Once in a month during entire construction period	Project Site	-

	Silt, Lead (as Pb)			
Marine Water Quality	pH, Temp, Salinity, TDS, TSS, DO, BOD, Hardness, Alkalinity, Chlorides, Turbidity, Conductivity, Oil and Grease, Heavy Metals	Once in a month both for low tide and high tide periods during entire construction period	3 locations viz. project site, upstream and downstream	-
Sediment Quality	Organic C, Organic N, heavy metals	Once in a month during entire construction period	3 locations viz. project site, upstream and downstream	-
Biological Parameters	Phytoplankton, Zooplankton and Benthic Communities	Once in a month during entire construction period	3 locations viz. project site, upstream and downstream	-
STP outlet	pH, BOD, COD, TSS, Oil and Grease	Once in month	-	CPCB Standards

6. ADDITIONAL STUDIES

This section describes about additional studies covering Compliance Report by RO-MoEF&CC, CRZ mapping, Hydrodynamic Modelling, Oil Spill Management Studies, Disaster Management Plan and Risk Analysis.

6.1. Certified Compliance Report of Existing Environmental Clearances

As per circular dated 30th May, 2012 issued by MoEF&CC, a certified report by RO, MoEF&CC on status of compliance of conditions on existing port is attached as ***Appendix I***.

6.2. HTL/LTL Demarcation

In order to comply with CRZ Notification, 2011 detailed HTL/LTL demarcation studies were conducted with respect to the project site. The study has been conducted by an authorized agency, Institute of Remote Sensing, Anna University Chennai, Tamil Nadu. HTL/LTL map in 1:4000 scale superimposing the project layouts have been prepared and is attached as ***Appendix II***.

6.3. Hydrodynamic modeling

MPT had entrusted Central Water and Power Research Station (CWPRS), Pune to study changes in hydrodynamics due to the proposed development and impacts due to dredging. CWPRS report is attached as ***Appendix III***.

The computational model considered for tidal flow simulation covered an area of 70 km x 40 km. the model area covers the entire proposed port area up to (-) 56 m depth contour. The maximum current size in the harbor area varies from 0.05 – 0.15 m/s.

The maximum tidal velocities at the entrance or in the harbor area re weak say 0.3 m/s, hence they are not large enough so to lift the bed material and bring the same into suspension. Most of the time, the sea currents are to be observed from South to North and the bed material to be dredged is very fine silty - clay type.

6.4. Oil Spill Contingency Response Plan

An Oil Spill Contingency Plan will outline the steps to be taken before, during and after a spill. Proposed development location falls within the port limit of the MPT hence, oil spill at proposed expansion if occurs, will be combated as per the prevailing Oil Spill Contingency

Response Plan of the MPT. The implementation of the Contingency plan for combating oil pollution off the coast of Goa is the responsibility of the Port Control Centre In-charge, MPT. Detailed plan is attached as ***Appendix IV***.

In case of an oil spill, immediate steps would be taken to contain and control the spill. Leakage has to be arrested in the shortest possible time. The following measures can be adopted:-

Oil spill on the land should be properly cleaned using absorbents, cotton waste, sand, saw dust etc.

Oil spill on berths should be properly cleaned using absorbents, cotton waste, and sand, saw dust etc., and the materials used for cleaning should be incinerated.

Major oil spills can be taken to oil separator and the same to be reused depending on the quality.

The collected oil is disposed to SPCB/CPCB authorized agency.

6.5. Hazard and Operability Study (HAZOP)

The objective of the HAZOP (Hazard & Operability) study is to aid in managing project risk through early identification of hazards and operability problems and to reduce the probability and consequences of an incident that would have a detrimental impact to the personnel, plant, properties and environment.

The objectives of the HAZOP study are:

- Identify and evaluate potential hazards and risks associated with process facilities
- Identify operability and maintenance issues
- Understand these hazards / issues and determine their potential consequences
- Determine (design and procedural) safeguards or risk reduction measures incorporated in the design and evaluate their adequacy
- Recommend additional safeguards or operational procedures as necessary

These steps will lead to a better design/ operation of the facility to mitigate the potential hazards identified.

This report presents a detailed record of recommendations proposed in instances where the HAZOP team believed that the existing safeguards were not adequate to manage the potential risks identified to acceptable levels. In total, the HAZOP study identified 38 recommendations for reducing the likelihood of a hazardous event occurring or reducing the severity of the consequence, should such an event occur. Given that recommendations were made to lower risks believed to be outside tolerable limits to an acceptable level (tolerable). Incorporation and close out of the all HAZOP recommendations listed above result in a facility where by all risks identified and managed to tolerable levels. Detailed HAZOP is attached as ***Appendix V***.

6.6. Quantitative Risk Assessment and Hazard Identification

A hazard is defined as "a physical situation with a potential for human injury, damage to property, damage to the environment or some combination of these. A major hazard is described as an imprecise term for a large scale chemical hazard, especially one which may be realized through an acute event".

Risk Assessment is described as "a process of collecting, organizing, analyzing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a major hazard installation and the measures needed to be taken to remove, reduce or control potential causes of such incidents".

Detailed QRA report is attached as ***Appendix VI*** and conclusions are given below.

Iso-risk contours have been plotted by PHAST Risk Micro software, Version-6.70 (Latest) of M/s DNV Technica. Iso-risk contour have been plotted by considering existing port facilities and other allied facilities. It may be inferred from the Iso-risk contours that acceptable limit of individual risk of $1.0x10^{-6}$ per year remains mainly confined within the proposed berth. It is also observed from FN curve that Societal Risk is in ALARP or tolerable range.

Hence, it may be concluded that with the normal operation, proposed berth may be considered safe from environmental risk point of view. Following OISD standards shall be complied on POL berth.

- OISD 156: for handling of petroleum products in ports

x OISD 117: transfer of petroleum products through pipelines

Fire Fighting facilities including Hydrants, monitors and Sprinklers systems Foam systems, Fire water pumps, ESD system, Interlocking system, Gas Monitoring system shall be installed in berth area. Personal Protective equipments are also being used. Following all safe operations procedures further reduces the frequency of incidents.

All the above systems should be maintained in good working order at all times. Awareness programs should be done for the people residing in nearby location of all types of emergency situations which may happen near berth with consultation with civic bodies.

7. PROJECT BENEFITS

Maritime transportation is a major means of international trade. The proposed development will mark a boost to the commercial activity in the region. Proposed modernization and expansion will lead to development of Vasco bay and thus will benefit the Mormugao Port by increasing the port capacity as well as helpful to the local people to improve their livelihood. The proposed development will improve the Port infrastructure for various activities such as fishing, cargo handling operations and tourism. Fishing industry will get boost through the development of modern fishing Jetty and other facilities which will lead to export of Marine products. Cruise facilities will positively impact the tourism industry. This will benefit the Port and hence the State of Goa

General Cargo berths 10 & 11 are having high berth occupancy and also they are being operated at low productivity. Additionally, evacuation is also seen as a major constraint. Deepening of existing berth No. 10 & 11 will accommodate large vessels and thus increase the handling capacity. Deepening of Breakwater berth will make it suitable to accommodate cruise of higher drafts and consequently influx of tourists will rise. Development of Coastal, Multipurpose, and POL berth will increase the handling capacity of General cargo and petroleum products like LPG, etc. With the construction of new Fishing jetty along with allied facilities in new location will caters the needs for fishermen community. The proposed development of modern fishing jetty will fulfill the long pending demand of local fishermen and hence community at large. Construction of Passenger Jetty gives an opportunity for a faster travel mode through waterways, which is benefitted to the local peoples as well as for tourists. Hence, there is highest necessity for the proposed development.

7.1. Employment Generation during Construction Phase

Construction phase will generate employment for local people including various subcontractors, electricians, machinists, welders, painters, blasters, riggers, pipe fitters and a number of administrative and managerial staff. Thus the proposed development will create employment opportunity in skilled and unskilled sectors. Moreover fabrication industries are entirely based on the order received by the concerned yard not a yearlong activity. If the order is more the employment opportunity is also more and vice versa. Hence most of the

man power required will be procured through the subcontractors, not directly employed by the Mormugao Port Trust.

The expected labour force required during construction phase is to the tune of about 70 persons. Although the workforce requirement will be temporary in nature, it will be met from the local population as far as possible hence there will be positive impact. Local businessmen will get opportunity to supply construction materials. Demands generated from the labour force for basic facilities including eatables etc. will increase the local business activity of the area.

7.2. Employment Generation during Operation Phase

Similar to the construction phase, the operation phase of the proposed development will also provide opportunities for employment mostly in the skilled and semi-skilled categories. This will enhance the income of the people associated with subcontracting business. All these activities will need support services like food, transport, medical facility etc. ultimately leading to improvement in quality of life of local people.

7.3. Other Benefits

The increased port activity results in increased direct financial returns from ships and cargoes

When compared to other transportation systems, water transport is environment friendly, as it is less polluting, with lower energy consumption.

The construction of fishing jetty with the ancillary facilities will be a boon to the local fisherman community.

The berths for liquid bulk and multipurpose cargoes will result in increased trade (both exports and imports).

The passenger jetty will also be a boon to the local residents and it enhances water transport and tourism.

8. ENVIRONMENT MANAGEMENT PLAN

Environmental Management Plan (EMP) is a site specific plan which is designed to ensure that the project is being implemented in an environmentally sustainable manner. Under the plan all the key stakeholders like nearby dwellers, workers, contractors, consultants, design engineers etc. will be informed of the risks that can arise at the site during the construction as well as operational phase of the proposed project, and how can they contribute in reducing those risks. EMP also ensures that the project implementation is carried out in accordance with the design and by performing appropriate mitigation actions reduce adverse environmental impacts on a long term period.

In this project EMP activities and fund flow shall be governed by Environment Management Cell (EMC) of MPT on account of maintenance of project activity. Also, the EMC will be the nodal agency interacting with the management with regards to the inputs required for EMP implementation and its operation.

Solid waste management system, traffic congestion management and other initiatives are also included in the EMP. Development of site for project activity to a certain extent, create inevitable impacts mainly during construction phase, but these impacts can be reduced significantly with the help of effective EMP. The potential environmental impacts, which need to be controlled, are the following:

- Air pollution due to the emission of particulate matter
- Noise pollution due to various noise generating equipment
- Wastewater generation from sanitary/domestic activities
- Solid waste Management (Collection- Process & Disposal)
- Labor camp with water, power, sanitation and medical facilities.
- Impact of dredging on marine environment

To ensure better environment in & around the project site as well as the neighboring population, an effective EMP is developed separately for construction and operation phases.

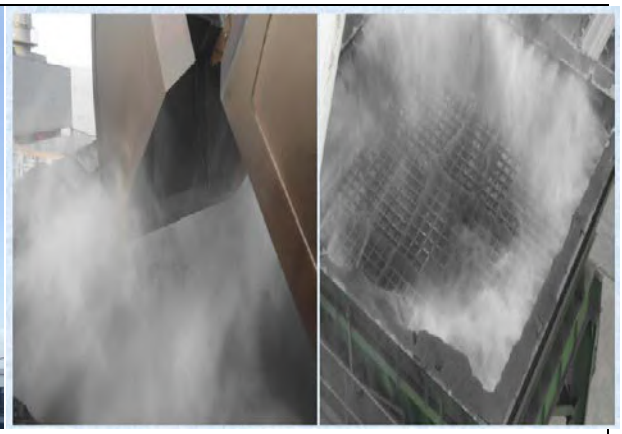
8.1. Existing Environment Management Practices of MPT

Sl. No.	Measures as proposed by GSPCB as directions	Action taken by MPT	Status
1	Trucks / tippers must ply on concrete / tarred roads only within MPT permissible speed limit. MPT should impose heavy penalty on defaulters.	The port has provided dedicated concrete roads on the periphery of the storage plot/area for truck/tipper movements.	Implemented
2	The stock piled dusty cargo on open MPT plots must be adequately covered with tarpaulin/HDPE sheets.	The cargo stock piles are being covered effectively with silpaulin/HDPE sheets.	Implemented
3	Trucks should not be overloaded with cargo and covered effectively with tarpaulin or HDPE sheets during transportation to desired destination.	Directions to stop overloading have been given and local RTA has been apprised of the issue and all trucks leaving the port premises are being covered effectively with silpaulin/HDPE sheets before it's despatch.	Implemented
4	The tyres and body of loaded trucks be cleaned by compressed air jet followed by water jet prior to allowing the trucks to leave port.	The tyres and body of loaded trucks are cleaned by compressed air jet prior to allowing the trucks to leave port.	Implemented
5	All dusty cargo handling/material transfer operations including unloading from vessel be discontinued/suspended temporarily during very strong/gusty winds.	Traffic supervisory staff is posted during material transfer operations to ensure stoppage of cargo handling during very strong/gusty winds. Mist Canon spray is also deployed during the transfer of dusty cargo to trap any	Implemented

		fugitive dust.	
6	Fixed wind shields/screens be erected with arrangement up to a height of 9m.	Fixed wind shields/screens have been erected for a length of 120m along Berth No.11 up to a height of 8.1m	Work completed
7	Lorries/wagons loaded with dusty cargo should be sprayed with water and adequately covered with tarpaulin /HDPE sheets prior to leaving for destination.	All lorries/wagons leaving the port premises are being covered effectively with silpaulin/HDPE sheets before it's despatch. Spraying of cargo with water before despatch is not practicable as it would affect the weight of consignment and also leach during transportation. Water is sprayed during loading of wagon to trap any fugitive dust	Implemented
8	The incomplete construction of 5.2 km stretch of NH-17B be completed on priority basis. The present traffic of trucks loaded with dusty cargo passing through port town Vasco-da-Gama be diverted to NH-17B.	This work of balance 5.2 kms stretch for construction of the 4-lane road is being executed by PWD, Govt. of Goa work order issued on 14.10.2015 with completion period of 3years. Work is in progress. Soil investigation work completed.	Work is in progress. This Road connectivity will by-pass cargo traffic from city

Apart from above measures MPT has developed 1,16,241 m^2 of greenbelt and further 6675 m^2 of greenbelt is proposed to be developed. Layout showing existing and proposed greenbelt is attached as ***Annexure VIII***.

Environmental Protection Measures Implemented by MPT

	
Bulk Cargo Handling System	Hopper with Aquadyne System
	
Closed Conveyers	Coal Covered with Tarpaulin
	
Water Spraying during Coal Stacking	Wind Screens

8.2. Environment Management Cell (EMC)

EMC's overall responsibility is the co-ordination of actions required for environmental management and mitigation, and for monitoring the progress of the proposed management plans and subsequent actions to be taken. The Cell is to be headed by a qualified Environmental Engineer and the other members of the cell that will include an environmental field scientist, Health & Safety Engineer.

The EMC will prepare a formal report on environmental management on regular intervals. Apart from responsibilities listed above, the EMC will also be responsible for the following:

- To implement the environmental management plan effectively
- To identify risks and control environmental problems
- To assure regulatory compliance with all relevant rules and regulations
- To minimize environmental impacts by strict adherence to the EMP
- To initiate environmental monitoring as per approved schedule
- To maintain documentation of good environmental practices and applicable environmental laws as ready references.
- To maintain environmental related records.
- To coordination with regulatory agencies, external consultants, monitoring laboratories etc
- To address all environment-related aspects as a dedicated group and will be responsible for the compliance to all environmental requirements–
- To manage post project-monitoring plan as per approved EIA & EMP
- To develop & maintain green belt

Institutional set up for Environment Management Cell (EMC)

The EMC is a decision making unit of the entire management mechanism. Following structure is proposed for the EMC. The institutional set up for EMC is given in Table 8.1.

Table 8.1: Institutional Set up for EMC

Sr. No.	Designation	Qualification	Responsibilities
1	Project Head- Environmental Health & Safety Engineer	M.Tech Civil	Overall project management
2	Manager- Environmental Engineer (Reporting to Project Head – EHS)	M.Tech Environment/ M.Sc. Env.	Implementation of EMP, compliance with regulatory conditions, Coordination with vendors
3	Health & Safety In charge (Reporting to Project Head – EHS)	M.Sc. Env.	Daily site inspection, compliance of EHS policies, reporting incidents,
4	STP Operator	M.Sc. Env.	Regular operation of STP during construction and operation phases.

The cell shall have all basic environmental management data of the project that includes:

- x Environmental Management Plan
- x All valid and up to date environmental and statutory clearances
- x All latest environmental legislations, standards, policies, codes and manuals for ready references
- x Contact details of all emergency response teams (Police, Hospital, Fire brigade, Coast Guard etc)
- x Environmental Safety and Management System (EMS)

The objective is to establish a system to assess, monitor and manage environmental performances, which can be used to promote continual environmental improvement and prevention of pollution. Suggestion is to adopt Environment, Health & Safety Management System (EHS MS) based on recognized international standards for environmental and safety management systems (ISO 14001; OHSAS 18001).

Table 8.2: Environmental Management Plan: Aspect Impact Matrix

Environment Management Plan – Construction Phase								
Activity		**Aspects**						
		Air	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Civil Construction	Impacts	Dust generation	Contamination of water bodies	Noise generating equipment	Contamination of soil with concrete Leaching of hazardous material	Hazardous Waste	Encounter with animals such as snakes, turtles, birds	Not envisaged. Construction site is within MPT limit.
	Mitigation	All materials must be stored in covered sheds to avoid fugitive dispersal due to wind	Wastage of water used for construction curing shall be avoided	Avoiding unnecessary use of horns and accelerating vehicles in the premises	Excess concrete shall be immediately removed from site	All staff and subcontractors will undergo a waste minimization and reuse management training	Maximum care should be taken to avoid disturbance to nearby vegetation.	
		Storage places should be designed as per material specifications/type, with all precaution of fire norms	Untreated sewage shall not be disposed into marine waters	Green belts and tree cover shall act as noise buffer	Hazardous waste management practices shall be followed	Procurement of materials will be planned and managed to avoid the over-ordering of products and minimize excess packaging is to be carried out.	Regular monitoring should be undertaken to find out any occurrence of fauna within construction site.	
		Adequate ventilation should be provided for storage of hazardous materials like paints, varnish cans etc. to avoid VOC emissions.	Regular site sanitation and maintenance of cleanliness around the labour camp will ensure sanitary conditions.	Acoustic enclosure for DG sets and regular maintenance will reduce noise.		Recycled material will be considered for use in all aspects of the project where feasible and reasonable in accordance with the Government's Waste Reduction and	Any animal if encountered should not be killed or hunted.	

						Purchasing Policy		
		Water sprinkling will be carried out on site for dust suppression				Any contaminated waste will be handled, separated, contained, managed and disposed of to prevent migration and further contamination.	List of NGOs conducting animal rescue should be maintained.	
		Use of covering sheets for trucks carrying construction material will prevent air borne dust.				The disposal of chemical, fuel and lubricant containers, solid and liquid wastes must be in accordance with the requirements of Goa Pollution Control Board.		
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Piled Foundation	Impacts	Drilling equipment exhaust	Increased Turbidity	Generation of marine noise	Not envisaged	Waste oil from equipment	Short term impact on productivity	Short term impact on fish landing. Beneficial for local fishermen once operational.
	Mitigation	Regular maintenance of pile driver equipment should be carried out to mitigate exhaust emissions.	Piling activity should be completed within stipulated time frame.	Piling activity should be completed within stipulated time frame.		The disposal of liquid wastes must be in accordance with the requirements of Goa Pollution Control Board.	Piling activity should be completed within stipulated time frame.	

				If possible piling activity should be moderated during dawn and dusk when fish activity is at peak.				
				Use of advance techniques such as bubble curtain shall be adopted				
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Concrete Works	Impact	Dust generation	Short term impact on water contamination	Noise generating equipment	Contamination of soil by materials used for construction	Waste water	Encounter with animals such as snakes, turtles, birds	Short term impact on fish landing. Beneficial for local fishermen once operational.
	Mitigation	Truck loading bays must be roofed and enclosed on three sides for 'back in' type plant or roofed and enclosed on two sides for 'drive through' type plant.	Concrete works should be completed within stipulated time frame.	Locating noisy equipment away from potential sources of conflict	Concrete mixing plants should be sited on land that is not flood prone.	Maximum care should be taken to avoid spillage of concrete in marine waters	Concrete should be carefully poured to minimize spillage. Complete isolation of the work area is required for cast-in-place concrete works near or below the high water mark of a water body.	
		Use water sprays or filtered dust extraction systems around gob hoppers and across open	Maximum care should be taken to avoid spillage of concrete in marine waters	Locating noisy equipment behind sound barriers or sound absorbers for example, gravel	Current and future proximity of sensitive land uses from concrete mixing plants should be	Concrete waste should be handed over to authorized recyclers		

		sides of enclosures.		stockpiles or constructed barriers	considered.			
		Speed limits on exposed road surfaces should be maintained < 40km/h.		Enclosing compressors and pumps		Concrete waste should not be dumped in CRZ areas		
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Steel Fabrication	Impact	No significant impact	No significant impact	Noise generating equipment	No significant impact	Waste water /Hazardous Waste	Encounter with animals such as snakes, turtles, birds	Short term impact on fish landing. Beneficial for local fishermen once operational.
	Mitigation			Locating noisy equipment away from potential sources of conflict		Waste/unusable weld rods shall be disposed of in a red skip tub or other container identified for scrap metal recycling.	All welding activities must be conducted in a manner as to prevent release of weld rods, metal chips, or any other debris into the marine water.	
						Waste solvent and solvent soaked rags or tools must be disposed of properly in a hazardous waste drum.		
						Contractor must provide hazardous waste drums and labels to its direct		

						subcontractors.		
						All subcontractors are required to follow all applicable environmental regulations as well as hazardous waste rules for handling and disposal of hazardous waste.		
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
	Impacts	Dust generation by materials used for painting such as VOC's	No significant impact	No significant impact	No significant impact	Hazardous Waste Generation	No significant impact	No significant impact
Painting	Mitigation	To minimize emissions of VOCs, any container holding paints, solvents, wastes, or other VOC-containing material must be kept closed unless a person is in the act of adding or removing material.				Waste paint, solvents, and contaminated work materials (paint brushes, rags, consumables, etc.) must be disposed of properly.		
		All “in-use” containers must be within line of site of the person using				Contractor must provide hazardous waste drums and labels to its direct		

		the container. All persons who handle paints, solvents or other VOC-Containing material must be trained.				subcontractors.		
		All containers of paints, solvents, and other hazardous materials are required to be clearly and correctly labeled as to contents at all times.				Contractor is required to follow all applicable laws as well as hazardous waste rules for handling and disposal of hazardous waste.		
		The contents can be transferred to an appropriate secondary container and labeled with a new product safety label.				Releases of chemicals, including paints and solvents, must be immediately reported to contractors.		
		All secondary containers must be capable of being completely sealed and compatible with the material being stored. Intentional damage to containers, such as puncturing the lids should be prohibited.						

		Empty containers shall be sent to the hazardous waste collection area.						
		All products are required to be mixed and used according to manufacturer's specification. Thinning of paints (addition of solvents) increases VOC content above allowable levels and should be strictly prohibited.						
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Dredging	Impacts	No impact	Increase in turbidity	Increase in marine noise	Disturbance of marine sediments	Generation of dredged spoil	Reduction in primary productivity, smothering of fish larvae	No impact
	Mitigation		Dredging should be limited to specified project area and completed within stipulated time frame	Dredging should be limited to specified project area and completed within stipulated time frame	Dredging should be limited to specified project area and completed within stipulated time frame	Dredged spoil should be dumped only at designated area. Dredged spoil should not be used for land filling in non CRZ area	Dredging should be limited to specified project area and completed within stipulated time frame	

Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
DG Sets	Impacts	Dust generation by materials used for painting such as VOC's	No significant impact	Noise generating equipment	No significant impact	Hazardous Waste Generation	No significant impact	No significant impact
	Mitigation	Regular maintenance of DG sets should be carried out to mitigate exhaust emissions.		Acoustic barriers should be provided to high noise generating DG sets		Waste oil generated from DG sets should be securely collected and disposed to authorized recyclers.		
		Adequate stack height should be provided for DG sets based on standard formula prescribed by Central Pollution Control Board (CPCB)		Noise levels should be maintained within CPCB limits		Drip trays and bunds should be provided to all DG sets to avoid contamination of soil		
Environment Management Plan – Operation Phase								
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Fish Landing	Impacts	Vehicular exhuast	Degradation of seawater quality	Increase in vehicular noise	No significant impact	Generation of fish waste, plastic waste	Reduction in primary productivity	Unpleasant working environment
	Mitigation	Regular maintenance of	Storm water, waste water generating	Avoiding unnecessary use of		Adequate containers will be strategically		Fish/ organic wastes collected

		trucks should be carried out to mitigate exhaust emissions	from fish washing area and auction hall shall not be disposed in sea directly	horns and accelerating vehicles in the premises		placed within the harbour complex for collecting the litter.		from the waste collection bins are brought to the organic waste converter platform for composting. Waste from the platform is shredded and then transferred to a organic waste composter
			Entire waste water should be routed through ETP			Separate (colored) closed PVC containers will be used to facilitate the segregation of waste into non-biodegradable waste, biodegradable organic waste.		
			Open defecation shall not be allowed					
			Sewage Treatment Plant shall be installed					
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Boat Maintenance	Impacts	No significant impact	Oil leak in seawater	No significant impact	No significant impact	Oily waste generation	No significant impact	No significant impact
	Mitigation		Appropriate oil recovery tools like			Segregation of oily waste and dispose to		

			containment booms and skimmers will useful in removing spilt oil from the harbour basin.			authorized recyclers		
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Operation of Liquids Cargo Berth	Impacts	No significant impact	Oil spill during handling	No significant impact	No significant impact	Oily waste generation	Smothering of marine fauna due to oil spill	Degradation of beaches Loss of livelihood
	Mitigation		Safety measures as per OISD standards shall be maintained.			Segregation of oily waste and dispose to authorized recyclers	Safety measures as per OISD standards shall be maintained.	Safety measures as per OISD standards shall be maintained.
			Precautionary measures suggested in Risk Assessment shall be adhered to				Precautionary measures suggested in Risk Assessment shall be adhered to	Precautionary measures suggested in Risk Assessment shall be adhered to
Activity		**Air**	**Water**	**Noise**	**Soil**	**Waste Generation**	**Ecology**	**Socio-economy**
Operation of Coastal Cargo Berth	Impacts	No significant impact	Storm water runoff	Operation of machinery and vehicles	No significant impact	Oily waste, Metal scrap and rubber scrap	No significant impact	Increased traffic on existing roads
	Mitigation		Proper storm water network shall be developed and routed through ETP	Regular maintenance of machinery and vehicles		Waste shall be disposed to authorized recyclers		

9. SUMMARY AND CONCLUSION

9.1. Project Introduction

Mormugao Port, commissioned in 1885 is one of the oldest ports on the west coast of India in the state of Goa and is blessed with a protected open type natural harbour. Over the years, it has developed a deep draft channel. With its location at the mouth of the Zuari River, it is a crucial component in the flourishing export industry of the state of Goa. It became one amongst the major ports of the country in 1964 and has been relentlessly serving the nation in its economic development.

Mormugao Port managed by the Mormugao Port Trust (MPT), currently has total 11 berths out of which 6 berths (Berth No. 1,2,3,5,6,7) are leased out to some other organizations and remaining 5 berths (Berth No. 4,8,9,10,11) are under the operation of Mormugao Port Trust. Significant cargoes handled at the Port include coal, ammonia and phosphoric acid fertilizer components, steel coil and slab, limestone, petroleum oil lubricants, molasses, and a small volume of containers. Non-cargo vessels include cruise ships, oilfield supply vessels, vessels of Navy, Coast Guard, NIO, Fisheries Survey of India etc. In addition, supplies for the Indian Antarctic expeditions are marshaled at Mormugao.

The existing facilities at Mormugao Port includes

- x Berths and Mooring Dolphins
- x Cargo Handling and Storage Facilities
- x Mechanical Ore Handling Plant
- x Streamloading, Discharging facilities, Port railway facilities and bunkering provisions
- x Cruise Tourism

Mormugao Port has a total operational area of 250 acres which is inadequate to cater to ever increasing trade demands. Temporary fish landing platform occupies prominent waterfront area close to Berth No.11 making development of Port infrastructure difficult. Mormugao Port Trust therefore proposes following Modernization and Expansion of Port Infrastructure:

g. Construction of Fishing Jetty.
h. Development of Berth for Liquid bulk (Petroleum products including LPG) and other General Cargo.

i. Development of Multipurpose Cargo Berth.
j. Construction of Passenger Jetty, Launch Jetty, and Port Craft Jetty.
k. Deepening of Berths 10 & 11 pockets from -13.10 to -15.0 m.
l. Deepening of Breakwater Berth from -9.5 to -11.5m

9.2. EIA Methodology

Detailed review of the feasibility report for the proposed development has been carried out. Ten km radius of study area was marked using latitudes and longitudes of the project site. For all major environmental components, primary and secondary data was generated and compared with the available historical/published information for assessment of various environmental components to develop the Environmental Management Plan (EMP).

Land use pattern, drainage and contour was mapped within 10 km radius from the proposed project site using remote sensing and GIS tools followed by ground truth verification. Baseline monitoring program was undertaken during March - May 2017 to establish the marine water qualities, marine sediment quality, soil quality, air quality, ground water and surface water quality and noise levels in the study area.

The AAQ data was collected during March 2017 to May 2017. The average meteorological conditions of the Mormugao were obtained from the observations of IMD Goa from 1981-2010. Ecology and biodiversity studies were carried out for terrestrial and marine components of the study area. The Marine biodiversity impact assessment report and management plan ton marine, brackish water and fresh water ecology and biodiversity was prepared by the National Institute of Oceanography (NIO) Goa. Field Survey was undertaken to develop socio-economic profile of the study area and was compared with published census data for further refinement.

A detailed review on the possible environmental pollutants such as emissions, siltation, liquid and solid wastes were undertaken. Impact Assessment of various environmental components have been carried out using standard EIA tools and techniques with appropriate input of primary and secondary baseline data to determine the significance of the impact. Various activities those are envisaged during construction and operation phases of the proposed project were evaluated for its significance. Based on the impact, suitable EMP was developed to mitigate the probable negative impacts.

9.3. Environmental baseline conditions

Land Environment

Different Physio-chemical Parameters of soil like Colour, pH, Electrical Conductivity, Organic Matter etc. were analysed during the monitoring. Landsat 8 cloud free data has been used for Landuse / landcover analysis and Cartosat-1data for analysing topographic features. Water body (73.36%) dominates in the present land use pattern covering 10 km surrounding of the proposed development area. 8.89% of lands have dense vegetation, while 4.33% have open vegetation. Barren lands were occupied 5.76% of the total land use. Built-up land use occupies in 4.36% and 2.66% areas were agricultural lands. Remaining land use were Sandy/Beaches (0.48%) and mangroves (0.16%). Due to the proposed development there were no variations in the existing land use pattern within the study area. But within in proposed development area there may be some minor change in land use to Built-up.

Surface and Groundwater Quality

To understand the status of ground water quality in the study area, ground water samples were collected from 2 locations in the study area. Samples were collected from bore well. In order to study the existing surface water quality within the study area, samples were collected from 3 different stations. Different Physio-chemical Parameters like Temperature, Turbidity, pH, Electrical Conductivity, Total Dissolved Solids, Total Hardness etc. were analysed during the monitoring.

Tides

The nature of tide prevailing at Mormugao is mainly semi-diurnal exhibiting two high and two low waters in a tidal day. The mean tidal variation is of the order of 1.6m at spring tide and around 0.7m at neap tides.

Bathymetry

Bathymetry details indicate that the seabed over a major portion of the surveyed area is generally smooth. Natural water depth (not including the dredged channel) increases gently from 4m along the eastern boundary to 8m near the harbor entrance, 3.5 km to the west.

In the western part, however, the water depths are extremely irregular, with depths increasing to more than 11m, while rocks outcrops are found within the northern boundary. The depths

within Vasco Bay between the eastern headland and the existing cargo Berth11 are generally less than 3.5 m below chart datum.

Marine Water Quality

Marine water monitoring was conducted in April 2017 to establish the existing status of seawater around the proposed project site. The study covered sample collection and analysis of physicochemical and biological characteristics of seawater and sediment samples. Marine water was collected from eight representative locations.

There was no significant difference in the water temperature which ranged between 26.9°C to 27.6°C in entire area. pH values were stable and did not show much variations. pH ranged between 7.6 to 7.9. The salinity of the water varied from 33.4 ppt to 37.0 ppt. The dissolved oxygen, the most important parameter that influences the health and diversity of biota, varied in 5.0 to 6.2 mg/L range indicating well mixing of water. In natural marine waters free from organic pollution the dissolved oxygen is generally close to 100% saturation. Depressed values at the project site indicate influence of oxidizable organic matter such as sewage entering the system.

Marine Sediments

Total Organic carbons in study area were between 0.7-2.8 % in subtidal sediment samples and 0.2-0.5 % in intertidal sediment samples. Organic Nitrogen concentrations were ranges between 338-1092 mg/kg in subtidal sediments samples and 23-97 mg/kg in intertidal sediment samples respectively. Total Phosphorus concentrations were 1437-8577 mg/kg in subtidal sediment samples and 215-248 mg/kg in intertidal sediment samples respectively while Iron concentrations were 8954-13029 mg/kg in subtidal sediment samples and 1135-9694 mg/kg in intertidal sediment samples at the respective stations. Manganese concentrations were 50-706 mg/kg in subtidal sediments and 14-20 mg/kg in intertidal sediment samples respectively. Zinc concentrations were 31-69 mg/kg in subtidal sediments and 9-10 mg/kg in intertidal sediment samples respectively.

Meteorology

Goa experiences a tropical monsoon climate under the Koppen climate classification. Goa, being in the tropical zone and near the Arabian Sea, has a hot and humid climate for most of

the year. The calendar year in the project area can be divided into four main seasons. The winter season lasts from December to February followed by pre-monsoon season from March to May. The monsoon season begins in June and continues up to mid-October. The period from mid-October to November constitutes the post-monsoon season.

Ambient Air Quality

AAQ data was monitored from seven sampling stations selected around the project site. AAQ data was monitored during March 2017 to May 2017. Parameters like PM2.5, PM10, Sulphur dioxide (SO2), Nitrogen Oxide (NOx) and Carbon Monoxide (CO) were measured during the monitoring period. The 24 hourly samples were collected twice a week.

x **Observations on PM2.5 levels**

The average concentration of PM2.5 at various stations monitored ranged from 23-39µg/m3. The highest PM2.5 value was recorded as 51µg/m3 near Shanta Durga Temple, Cortalim and lowest value of 19µg/m3 was recorded near NIO Guest House, Dona Paula. The PM2.5 values monitored during the field survey were within the permissible limit of 60µg/m3 for industrial, residential, rural and other areas.

x **Observations on PM10 levels**

It is observed that average concentration of PM10 at various stations ranged from 43-82 µg/m3. The highest PM10 value was recorded as 92µg/m3 near Sparkle Service Station, Vasco da Gama and lowest values of 40µg/m3 were recorded near NIO Guest House, Dona Paula and Aguada Light House, Aguada. The average PM10 values monitored during the field survey were generally within the permissible of 100µg/m3, limits except at few occasions for industrial, residential, rural and other areas.

x **Observations on SO_2 levels**

From ambient SO2 level as monitored during field studies the average concentration of SO2 at various stations in the study area was well below the prescribed limit of 80µg/m3 specified for industrial, residential, rural and other areas. The average concentration of SO2 at various stations monitored ranged from 11-20µg/m3. The highest SO2 value was recorded as 25µg/m3 near Sparkle Service Station, Vasco da Gama and is below detectable limit in all the locations.

x **Observations on NOx levels**

It is observed that during the study period, average NO2 concentration at various sampling stations ranged from 17-31µg/m3. The highest NO2 value was recorded as 34µg/m3 near Shanta Durga Temple, Cortalim and lowest value of 10µg/m3 was recorded near Aguada Light House, Aguada. The average concentration of NO2 at various stations in the study area was observed to be well below the prescribed limit of 80 µg/m3 specified for industrial, residential, rural and other areas.

x **Observations on CO levels**

The average concentration of CO at various stations monitored ranged from 0.7-1.3 mg/m3. The highest CO value was recorded as 1.3mg/m3 near Sparkle Service Station, Vasco da Gama and lowest value of 0.7 mg/m3 were recorded from Shanta Durga Temple, Cortalim and Glenwood Garden Main Gate, Bambolim. The CO values monitored during the field survey were below permissible limit of 2 mg/m3 for industrial, residential, rural and other areas.

Noise Levels

The day time equivalent noise level ranged from a minimum of 50.4 dB (A) to a maximum of 75.2 dB (A). The night time equivalent noise level ranged from a minimum of 40.3 dB (A) to a maximum of 62.7 dB (A). The proposed study area is located within the industrial area. Permissible noise limits for industrial area prescribed by CPCB are 75 dB (A) during day time and 70 dB (A) during night time. Recorded noise levels were observed to be within the required limits except at Zuari Nagar were noise level observed as 75.2 dB (A).

Marine Ecology

In the present study period, species belonging to four groups namely diatoms, dinoflagellates, blue greens and cocolithophores were recorded. Of these, diatoms were found to be the dominant group. Dinoflagellates were second dominant group followed by blue green algae Cocolithophore. Zooplankton groups namely Calanoida, Cyclopoida, Harpacticoida and other larval forms were recorded. Among the zooplankton, Calanoida were found to be the most dominant group. Four groups of benthic organisms namely polychaetes, crustaceans, bivalves

and gastropods were recorded. Polychaetes constituted the dominant group followed by gastropods, crustaceans and bivalves.

Terrestrial Ecology

Vegetation in urban area is dominated by native as well as exotic species such as Cocos nucifera, Azadirachta indica, Delonix regia, Ficus spp and Zizyphus mauritiana. In general, flora of study region was observed to be healthy and highly diverse. Overall 80 species of birds were observed in various habitats among study area during survey period. Water bodies like rivers and creeks were inhabited by Egrets, Cormorants, Herons, Ibis and Sand Pipers. Two species of kingfishers were recorded. Terns, Godwits and Redshanks were occasionally seen near small streams pouring into Zuari River.

Due to absence of dense vegetation mammalian density of this region was observed to be very low. No schedule I species was recorded from entire study area. Moreover, forest cover map of Goa shows that this region do not comprise any major forest range or block. Hence, no wildlife data pertaining to this region is available. Crocodiles have found an ideal habitat in the Cumbarjua canal and mangrove swamps. However, the habitat of marsh crocodile is considerably away from proposed project site.

Socio-economy

Socio-economic assessment of the study area has been prepared based on secondary data extracted from Primary Census Abstract, Census of India 2011. The issues under focus in this topic are demographic pattern, economic activity, education and literacy profile, etc. The assessment attempts to predict and evaluate the future impacts of project upon people, their physical and psychological health and well-being, their economic status, cultural heritage, lifestyle and other value system.

The study area comprises of 40 settlements, including 20 Municipal Corporation wards, 8 Census towns, 8 rural villages and 4 out growths. The total population in the study area includes 314986 persons, of which, about 10.02% comprises of children below the age of 6 years as per Census of India 2011.

9.4. Predicted impacts

There will not be any major impacts due to the location of the proposed development. The proposed project activities are planned within existing port area; hence no land acquisition is required. Moreover, proposed fishing harbor and passenger jetty projects are beneficial for boosting local economy.

The only land parcel involved in this proposal is back up area of coastal and general cargo berth. Development of fishing harbor, passenger jetty and liquid berth will be on reclaimed land. Handling of any liquid or bulk cargo is not envisaged from coastal cargo berth. Hence, contamination of land through leaching is not possible.

No fresh water surface bodies are present at the proposed project site. Moreover, construction activities are confined to marine areas. Hence, there will be no significant impacts on surface water. The average no. of construction labourers likely to be deployed for the execution of the proposed project will be about 70. No labour camps are envisaged at the project site as the labours will be local residents and the existing sanitation facilities of Mormugao Port will be sufficient. The total water requirement for domestic purposes during construction phase has been estimated as 3.5 m^3/day and the quantity of domestic sewage likely to be generated during construction phase will be about 3 m^3/day.

Impacts on the marine ecology during the construction phase can be due to modifications in the hydrodynamic characteristics of the area, impacts on water and sediment qualities and impacts on fishing activities. Sediment samples analyzed from the project area did not show the presence of any appreciable levels of contamination and hence may not pose any problems of contamination. Dredged spoil will be disposed at pre-designated site of Mormugao Port Trust.

Pile driving, deposition of rubble, dredging, sand compaction and other construction activities increase the turbidity levels in the coastal water which is a short term impact. The turbidity level returns to the pre-project level after the completion of construction activities.

Construction activities will pose impact on the biota in the pile-footprint areas of berth and reclamation area. Project site does not sustain seaweeds or mangroves. Hence, no further impacts on marine macrophytes are envisaged. Primary production in this region is moderate

and reduction in productivity will be confined to a small segment of the marine zone due to construction activities.

Disturbance from construction activities may cause displacement of fishery resources and other mobile bottom biota. Dredging removes bottom biota and dumping of dredged material covers bottom habitat, both of which may reduce fishery resources. Settlement of re-suspended sediments on fragile marine fauna and flora damages the ecosystem particularly coral reefs. However, corals near Grande Island are almost 7 km away from construction site. Hence, impacts of construction activities on corals are remotely possible.

The major pollutant in the construction phase is Suspended Particulate Matter (SPM) being air-borne due to various construction activities. The vehicular movement generates pollutants such as NOx, CO and HC. But, the vehicular pollution is not expected to lead to any major impacts. The impact on air environment during construction phase is expected to be local and reversible. The combustion of diesel in construction equipment could be one of the possible sources of incremental air pollution during the construction phase.

Fish/ organic wastes collected from the waste collection bins are brought to the organic waste converter platform for composting. Waste from the platform is shredded and then transferred to a organic waste composter machine where the waste is mixed with a suitable absorbent like paper or sawdust. This is followed by addition of bacterial inoculums inside the converter for organic waste digestion. The raw digested material is left for curing for about 15 days to get good quality compost. The compost can be used as manure for the greeneries in and around the Port.

The non-degradable waste will be first segregated so as to remove the material that can be recycled. Metal items shall be collected and sold to scrap dealers. Tyres can be turned into fenders. The plastic materials are to be collected and periodically handed over to authorized scrap dealers. Hazardous waste such as oily rags, empty drums, waste oil shall be disposed to recyclers authorized by Goa Pollution Control Board.

9.5. Mitigation measures

The construction waste generated shall be partly used for land filling and restoration of the project site. Balance material will be disposed as per the guidance of Mormugao Municipal

Authority at designated sites. The Hazardous Solid Waste shall be treated as per the Hazardous waste management Rules 2016.

Construction activity shall be completed within designated period. Dredging must be confined to project area and must be completed within stipulated time period. Dredging and associated activities should be avoided during the notified fish breeding season (June-July) which is considered as egg laying and larval recruitment season.

Discharge of waste wastes into sea should be prohibited. Spill control measures shall be adopted while bunkering dredgers and fishing boats, etc. Any effluent generating from fishing harbor, auction hall, ice plant etc shall be treated in ETP.

An adequate drainage system should be provided at the site with separate collection streams to segregate the storm run-off from roads, open areas, material storage areas, vehicle wash water and other wastewater streams. No construction shall be permitted during rainy days or extreme climatic conditions. Suitable measures will also be taken to prevent the washing away of construction materials into the drainage system. Contaminated storm water will be collected and conveyed to sedimentation tank for removing grit.

9.6. Quantitative Risk Assessment

Acceptable limit of individual risk of $1.0x10^{-6}$ per year remains mainly confined within the proposed berth. It is also observed from FN curve that Societal Risk is in ALARP or tolerable range.

Hence, it may be concluded that with the normal operation, proposed berth may be considered safe from environmental risk point of view.

Fire Fighting facilities including Hydrants, monitors and Sprinklers systems Foam systems, Fire water pumps, ESD system, Interlocking system, Gas Monitoring system shall be installed in berth area. Personal Protective equipments are also being used. Following all safe operations procedures further reduces the frequency of incidents.

All the above systems should be maintained in good working order at all times. Awareness programs should be done for the people residing in nearby location of all types of emergency situations which may happen near berth with consultation with civic bodies.

9.7. Project benefits

Maritime transportation is a major means of international trade. The proposed development will mark a boost to the commercial activity in the region. Proposed modernization and expansion will lead to development of Vasco bay and thus will benefit the Mormugao Port by increasing the port capacity as well as helpful to the local people to improve their livelihood. The proposed development will improve the Port infrastructure for various activities such as fishing, cargo handling operations and tourism. Fishing industry will get boost through the development of modern fishing Jetty and other facilities which will lead to export of Marine products. Cruise facilities will positively impact the tourism industry. This will benefit the Port and hence the State of Goa.

10. DISCLOSURE OF CONSULTANT

This EIA report is prepared on behalf of the Mormugao Port Trust, taking inputs from proponent's office staff, their consultants, Architects, Project Management Professionals etc. by Environmental Consultants M/s Ultra-Tech Environmental Consultancy & Laboratory, who have been accredited by QCI-NABET vide certificate no: NABET/EIA/1417/RA010

Ultra-Tech not only gives environmental solutions for sustainable development, but make sure that they are economically feasible. With innovative ideas and impact mitigation measures offered, make them distinguished in environmental consulting business. The completion of tasks in record time is the key feature of Ultra-Tech. A team of more than hundred environmental brigadiers consists of engineers, experts, ecologists, hydrologists, geologists, socio-economic experts, solid waste and hazard waste experts apart from environmental media sampling and monitoring experts and management experts , strive hard to serve the clients with up to mark and best services.

Ultra-Tech offers environmental consultancy services to assist its clients to obtain environmental clearance for their large buildings, construction, CRZ, SEZ, high rise buildings, project projects and industries covering sugar and distilleries from respective authorities. Ultra-Tech is in the process of getting QCI-NABET final accreditation for its EIA organization.

Ultra-Tech also provide STP/ETP /WTP project consultancy on turn-key basis apart from Operation and Maintenance of these projects on annual contract basis. Also, having MoEF approved environmental laboratory, Ultra-Tech provide laboratory services for monitoring and analysis of various environmental media like air, water, waste water, stack, noise and meteorological data to its clients all over India and abroad.

SCHEDULE - I

FACILITIES PROPOSED TO BE PROVIDED IN FISHERY HARBOUR:-

		PLINTH AREA
1. SECURITY	-	27.24 sq.m
2. OFFICE & RADIO COMMUNICATION	-	181.64 sq.m
3. AUCTION HALL - 3 Nos. (80m x 12m)	-	2880.00 sq.m
4. TOILET - 2 Nos	-	135.46 sq.m
5. CANTEEN /RESTAURANT	-	127.70 sq.m
6. REST SHED - 2 Nos.	-	426.80 sq.m
7. NET MENDING SHED	-	206.95 sq.m
8. GEAR SHED - 2 Nos.	-	322.60 sq.m
9. WORKSHOP	-	95.34 sq.m
10 PETROL PUMP - 2 Nos.	-	150.00 sq.m
11. SUMP/OVER HEAD WATER TANK	-	100.00 cum
12. ELECTRICAL SUB-STATION		
13. EFFLUENT TREATMENT PLANT (ETP)	-	500.00 sq.m

SCHEDULE - II

PROPOSED DEVELOPMENT AREA FOR FISHERY HARBOUR:-

1. BACK UP AREA	-	27360 sq.m
2. JETTY AREA	-	2560 sq.m
3. SLIP WAY	-	1500 sq.m
4. AREA NEAR APPROACH	-	3580 sq.m
TOTAL AREA	-	35000 sq.m (Approx.)

SCHEDULE - III

PROPOSED AREA FOR REHABILITATION:-

1. Area - 1	-	8840 sq.m
2. Area - 2	-	8760 sq.m
3. Area - 3	-	2300 sq.m
TOTAL AREA	-	19900 sq.m (approx.)

SCHEDULE - IV

FACILITIES PROPOSED TO BE PROVIDED FOR TRADITIONAL FISHERMEN AT KHAREWADA:-

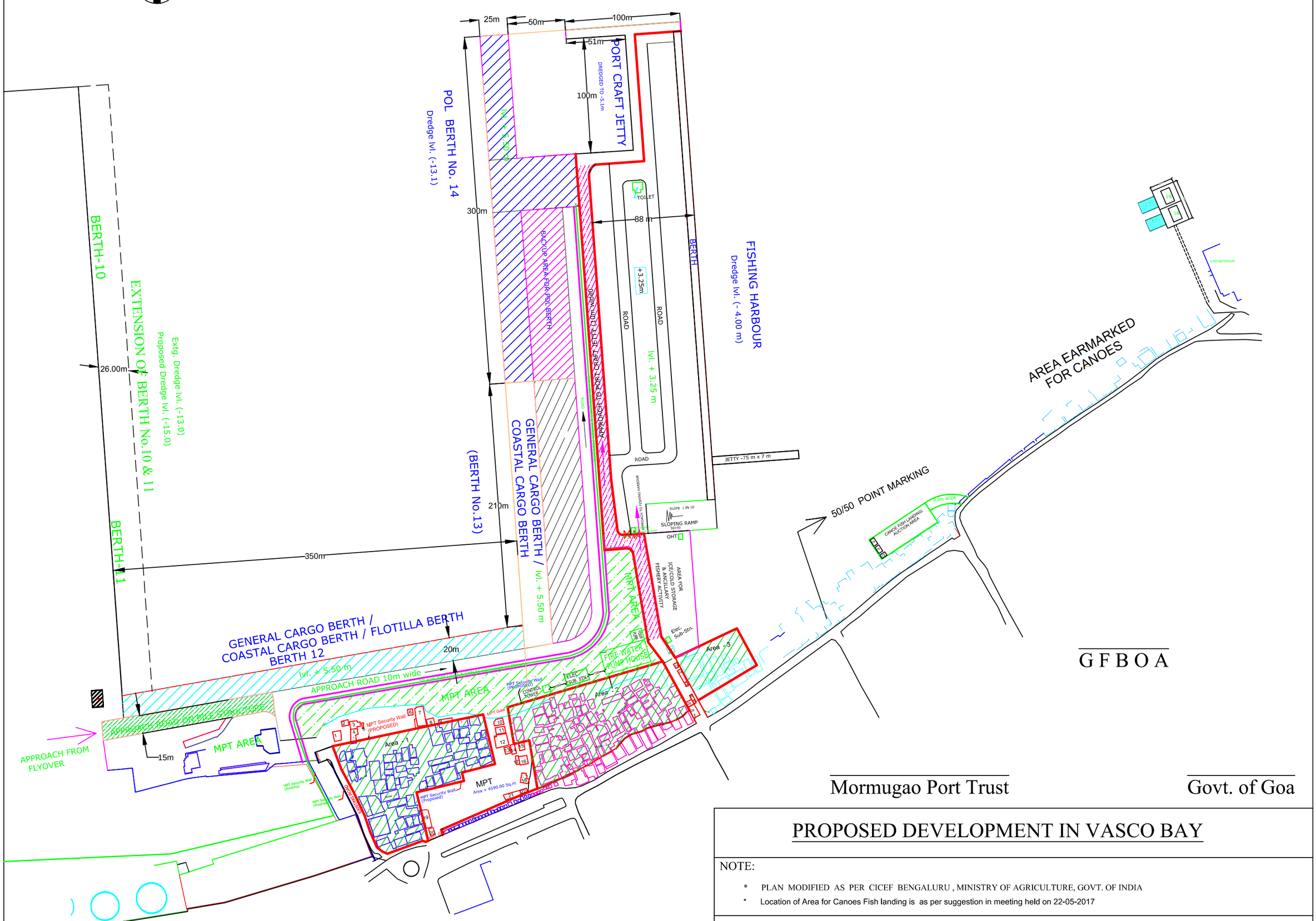
14. OFFICE AND RADIO COMMUNICATION	-	100.00 sq.m
15. TOILET	-	34.29 sq.m
16. NET MENDING SHED (2 NOS)	-	206.95 sq.m
17. RAMP - 2 NOS	-	836.00 sqm

CONCEPTUAL PLAN OF VASCO BAY DEVELOPMENT

TIDE LEVELS

HHW : (+) 2.30m
MHHW : (+) 1.90m
MLHW : (+) 1.80m
MHLW : (+) 1.00m
MLLW : (+) 0.50m
MSL : (+) 1.30m

** ALL LEVELS w.r.t CHART DATUM



Mormugao Port Trust

Govt. of Goa

PROPOSED DEVELOPMENT IN VASCO BAY

NOTE:

* PLAN MODIFIED AS PER CICEF BENGALURU , MINISTRY OF AGRICULTURE, GOVT. OF INDIA
* Location of Area for Canoes Fish landing is as per suggestion in meeting held on 22-05-2017

SCALE - 1:2500 PLAN No. :- H/ AUG.2017