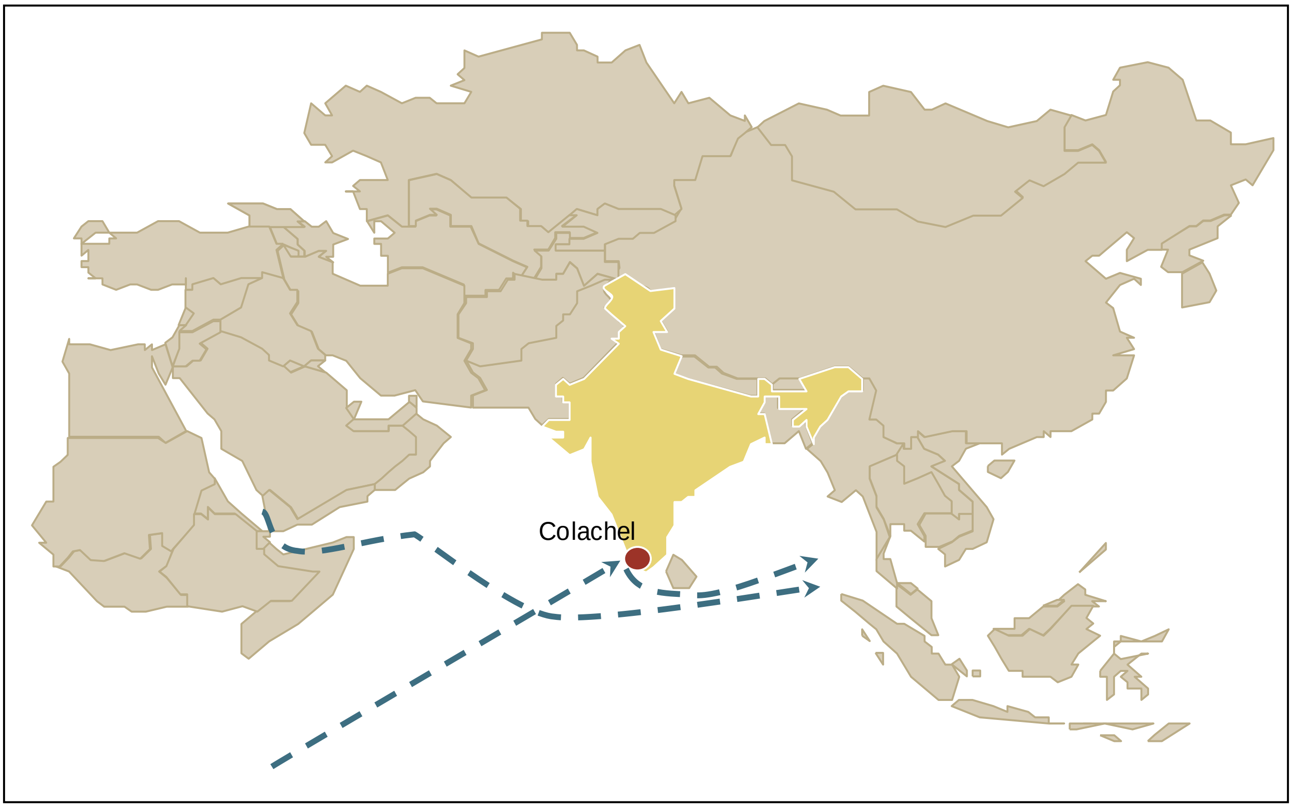

V.O.Chidambaranar Port Trust

Preparation of Rapid Techno-Economic Feasibility Report for Development of Colachel Port in Tamilnadu

Final Report (Revised) Dated 14.08.2015

Volume 1 of 2: Report

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Glossary

A-RMG	Automated Rail Mounted Gantry crane
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CFS	Climate Forecast System
CFSR	Climate Forecast System Reanalysis
CHA	Custom House Agent
CRZ	Coastal Regulation Zone
CSD	Cutter Suction Dredger
CSR	Corporate Social Responsibility
DCF	Discounted Cash Flow
DPR	Detailed Project Report
EDI	Electronic Data Interchange
EGM	Export General Manifests
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Analysis
ESMP	Environmental and Social Management Plan
EXIM	Export & Import
GDP	Gross Domestic Product
GoI	Government of India
GOT	Global Ocean Tides
GT	Great Diurnal Range
HAT	Highest Astronomical Tide.
HHWS	Highest High Water Spring
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities.
IEE	Initial Environmental Examination
IGM	Import General Manifests
IPA	Indian Ports Association
IRE	Indian Rare Earths Ltd.
IRR	Internal Rate of Return

JNPT	Jawaharlal Nehru Port Trust
LAT	Lowest Astronomical Tide
LLWS	Lowest Low Water Spring
MAT	Minimum Alternate Tax
MDA	Maximum Dissimilarity Algorithm
MHHW	Mean Higher High water
MHLW	Mean Higher Low Water
MLHW	Mean Lower High Water
MLLW	Mean Lower Low Water
MoEF	Ministry of Environment and Forest
MSL	Mean Sea Level
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
O&M	Operation and Maintenance
PIANC	Permanent Association of Navigation Congresses
POL	Petroleum, oil and lubricants
PPE	Personal Protective Equipment
PPP	Public Private Partnership
RBF	Radial Basis Function
R&D	Research & Development
RMG	Rail-Mounted Gantry crane
RMS	Royal Mail Ship
RS	Reach Stacker
RSC	Roll-over Safety Coefficient
SAGT	South Asia Gateway Terminals
SC	Shuttle Carrier
SEZ	Special Economic Zone
SHG	Self Help Groups
SSC	Sliding Safety Coefficient
STS	Ship-to-shore gantry crane

SWAN	Simulating Waves Nearshore
TAMP	Tariff Authority for Major Ports
TAT	Turn Around Times
TEFR	Techno-Economic Feasibility Report
TEU	Twenty-foot Equivalent Unit (shipping container)
TNMB	Tamil Nadu Maritime Board
TOS	Terminal Operating System
TPA	Tonnes per annum
TS	Trans-shipment
TSHD	Trailing Suction Hopper Dredger
UKC	Under Keel Clearance
VAT	Value Added Tax
VGF	Viability Gap Funding
VISA	Visa International Service Association
VOCPT	V.O. Chidambaranar Port Trust
VTMS	Vessel Traffic Management System
WW3	Wave Watch 3
YoY	Year over Year

1. BACKGROUND

1.1. GENERAL

Container traffic in India has seen tremendous growth in the last decade. The traffic has grown by more than 10% CAGR. The traffic is expected to continue growing at this rate as the global economy recovers and India's GDP growth rate accelerates back to 7 – 8% YoY growth. The demand for container traffic can further accelerate if the plans for debottlenecking of logistic infrastructure are implemented in time and the 'Make in India' push drives greater exports and manufacturing outsourcing to India.

In order to support this accelerated cargo growth and also, to enable 'Make in India' initiatives, it will be important to plan additional capacities and drive greater port productivity.. As of now, there are only a few ports in India that have sufficient draft and match global cargo handling efficiencies.. This has resulted in a large percentage (~25%) of containers that originate from India to be trans-shipped in foreign ports such as Colombo, Singapore, Klang etc. This is leading to an economic loss for the country and an economic dependence on foreign ports. Hence, the Ministry of Shipping (Government of India) through VOC Port Trust has asked the consultant to identify a suitable site and assess feasibility of developing a new container trans-shipment port on the Southern coast of India near Colachel.

Colachel is located on the south-west coast of India. It is a strategic location given its proximity to the international East-West shipping route. This route accounts for a major share of the total global container traffic flows and the mainline vessels use this route for transporting cargo between US, Europe and Asia. A significant share of India's current container cargo also moves through this route. The following figure shows proximity of Colachel to the east-west mainline shipping route.

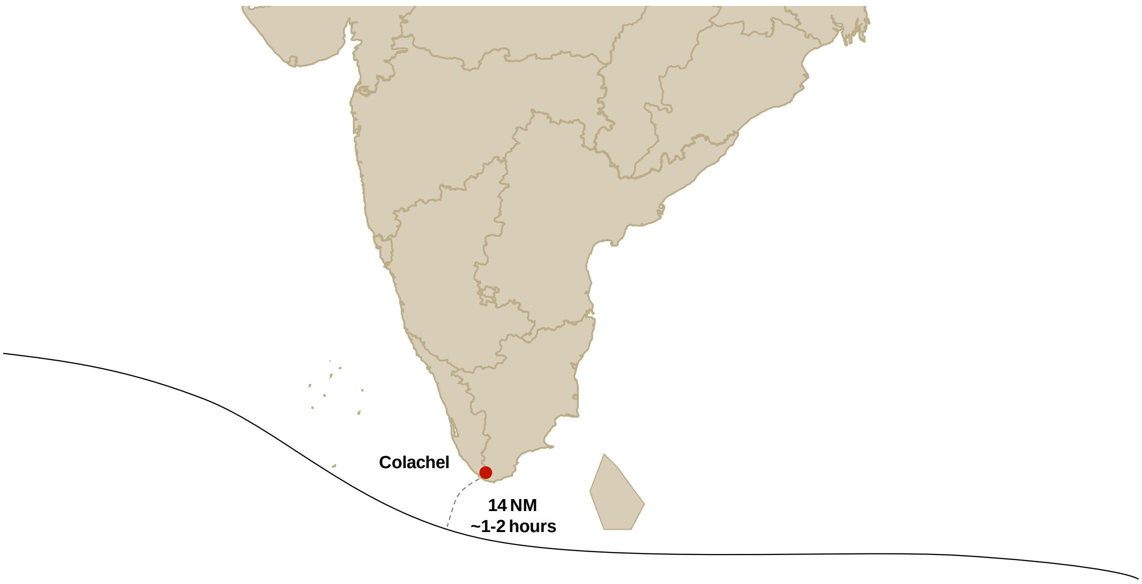


Figure 1: Proximity of Colachel to main shipping line

Additionally, Colachel has a natural deep draft which makes it viable for servicing large sized vessels, which is an important factor in attracting shipping lines. Global vessel sizes have significantly increased in the last decade and most main liner vessels have capacities of 10,000 TEUs and above, with the largest vessel reaching a capacity of 18,000 TEUs. .

This document is a Final Report that summarises the findings of the Techno-Economic Feasibility study and provides recommendations for development of the port.

1.2. INDIA'S TRANS-SHIPMENT TRAFFIC: AN UNADDRESSED OPPORTUNITY

Indian ports handled ~10.9 M TEUs of container cargo in 2014. Nearly 75% of this cargo was gateway (7.5 Mn TEUs), while ~25% was trans-shipped (TS) en-route to destination (2.8 Mn TEUs). Currently, all of India's trans-shipped cargo gets handled in ports outside of India. Colombo, Singapore and Klang handle more than 80% of this cargo, while Colombo alone handles around 1.2 Mn TEUs. Figure 1 below gives a detail port wise breakup of India's transhipment traffic.

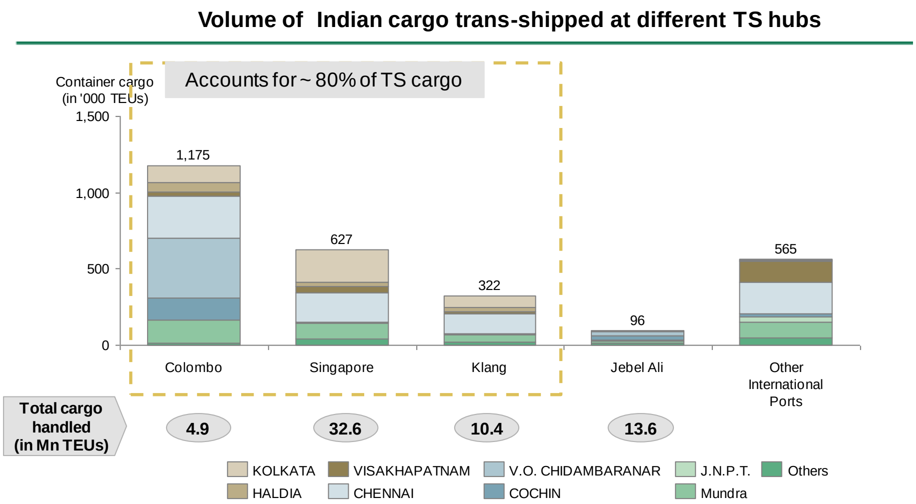


Figure 2: Key TS hubs for Indian container cargo

India has not been able to create an attractive trans-shipment port alternative that can match the competing international ports on location, draft and overall cost economics. This has been the key reason for losing out on this opportunity to international ports. A compelling case however exists for attempting to change this scenario, mainly because of the following reasons:

1. <u>~Rs 1,500 Cr of potential port revenue (opportunity) loss per annum</u>

Indian port industry loses out upto Rs. 1,500 Cr of revenues each year on trans-shipment handling of cargo originating / destined for India. This translates into an estimated total loss of Rs. 3,000-4,500 Cr to economy (assuming an economic multiplier of 2 – 3x for ports). The loss is even higher if opportunity to handle cargo emerging from other countries in the region is considered.

2. <u>Inefficient logistics for a large segment of India's EXIM industry situated in South India</u>

Trans-shipment of cargo results in logistic cost inefficiencies for Indian industry (especially from South India) given the extra port handling charges incurred at the trans-shipment hubs. The cost of this additional port handling is to the tune of USD 80-100 per TEU, which would be saved if the container is imported/ exported as direct gateway cargo instead of being trans-shipped. The figure below illustrates this cost inefficiency using an example of cargo movement for a typical exporter from Madurai, T.N. using trans-shipment in Colombo and shipping to Antwerp in Europe.

	TS route through Colombo	Cost (in USD / TEU)	Gateway route through Colachel	Cost (in USD / TEU)
Inland Transport	**Madurai to Tuticorin**	70-75	**Madurai to Colachel**	120-130
Port Charges	**[illegible]ıdling charge**	120-130	**-**	-
	Colombo handling charge	75-80	**Colachel handling charge**	75-80
Shipping costs	**Tuticorin to Colombo**	8-10	**Colachel to Antwerp**	65-70
	Colombo to Antwerp	65-70	**-**	
Total	**Overall logistics cost**	~350		~250

Upto 100 USD/ TEU of logistics cost can be saved for Madurai exporters by routing traffic through Indian gateway port

Figure 3: Simulation: Transport cost breakup for exports from Madurai district

A significant share of this cargo can be converted to Gateway by strategically locating a port near the Southern tip of India. This could also potentially help in further growth of trade due to improved cost competitiveness.

3. Opportunity to become a large trans-shipment hub for trade between US, EU, Africa and Asia

Container trans-shipment in Asia mainly occurs on three key routes – 1) US/ Europe to/from Far East, 2) Africa to/from Asia primarily Far East , 3) US/ Europe to/from India and Indian sub-continent.. The routes to/from Europe and America are the biggest routes as per current cargo traffic (combined ~60 Mn TEUs). Africa bound traffic although relatively smaller today (~10 Mn TEUs), it is expected to grow at a faster rate (6-7%) over the next few decades.

Routes	Traffic Volumes (in Mn TEUs)	Expected traffic growth (in % YoY)
Europe to/ from Asia[1]	30	4-5%
North America to/from Asia[2]	28	4-5%
Africa to/from Asia	10	6-7%

1. Includes Europe to Asia and Europe to India, Indian Sub-Continent traffic 2. Includes . Includes US to Asia and Europe to India, Indian Sub-Continent traffi
Source: BCG Analysis, IHS trade data

Figure 4: Route wise Traffic volumes

Currently, Asia has 3 main transhipment port clusters - Middle East Hub, South Asia Hub and S.E.Asia Hub. The following figure describes these clusters and the volume of traffic handled by each.

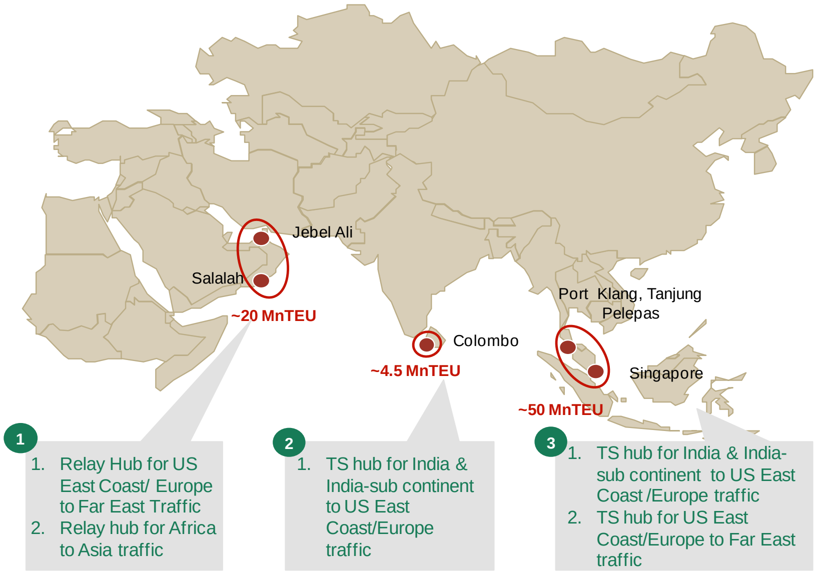


Figure 5: Major TS hub clusters in Asia

While, most of the transhipment trade happens in the South East Asian and Middle East cluster, the South Asian location (including Southern tip of India) is in-fact the most efficient location for transhipment of cargo moving to Africa, EU or East Coast of America.

i. Indian-subcontinent to US/ Europe traffic currently trans-shipped in Singapore cluster

Currently, ~70% of cargo from Bangladesh and Myanmar gets trans-shipped in Singapore. A trans-shipment hub at the Southern tip of India can save voyage time by 5-6 days for cargo bound to Africa, EU or East coast of America, resulting in potential cost savings of 12-15%. Currently, only Colombo port is the alternative in the South Asia zone with a capacity of ~5 Mn TEU. Whereas, the South East Asian cluster already handles more than 50M TEUs. Thus, due to this significant scale difference South East Asia continues to be the main aggregation point. Emergence of new hubs such as Colachel and further growth of Indian container cargo traffic can change this scenario in the near future.

Indian sub-continent to/from Europe/ West Coast US			
Current Route	**Voyage time (in days)**	**Route with Indian TS hub**	**Voyage time (in days)**
Chittagong to Singapore (feeder)	5-6	Chittagong to Colachel (feeder)	4-5
Singapore to Antwerp	25-26	Colachel to Antwerp	20-21
Total voyage time	**30-31**	**Total voyage time**	**25-26**

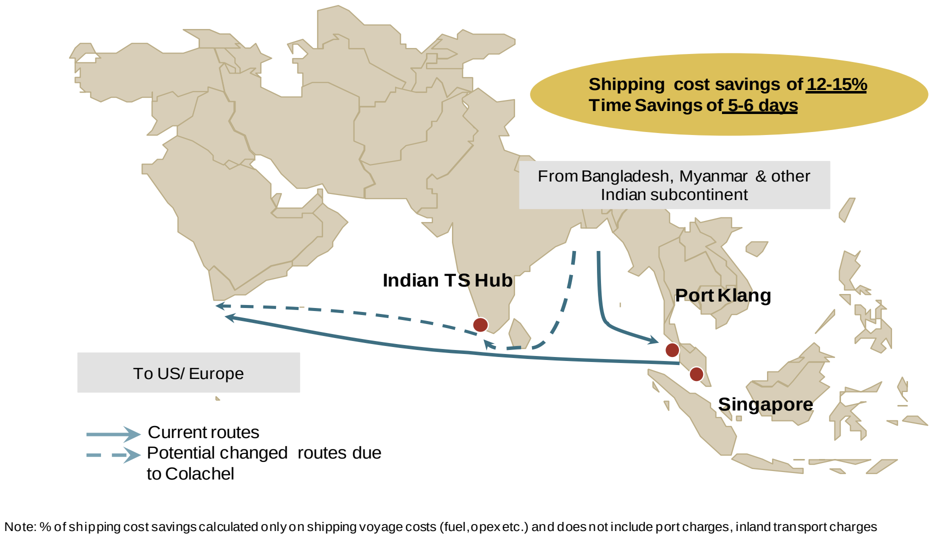


Figure 6: Potential time and cost savings for liners by using Colachel (I)

ii. US/ Europe to Far East traffic currently trans-shipped/ relayed in the Middle Eastern TS hub

US/ Europe to Far East (including China) is the busiest trade route with volumes of ~30 Mn TEUs. Liners have started using the Middle Eastern cluster ports, mainly Salalah and Jebel Ali as relay hubs for this route, with one service bringing cargo from China to Salalah, while another service picks up this cargo and moves to US West Coast. TS port in South India is well placed to attract some of this relay traffic as it will account for ~1 day voyage time saving and 2-3% shipping cost savings.

Europe/ West Coast US to/from Far East			
Current Route	**Voyage time (in days)**	**Route with Indian TS hub**	**Voyage time (in days)**
Antwerp to Salalah	~16	Antwerp to Colachel	~20
Salalah to Shanghai (relay)	~17	Colachel to Shanghai (relay)	~12
Total voyage time	**~33**	**Total voyage time**	**~32**

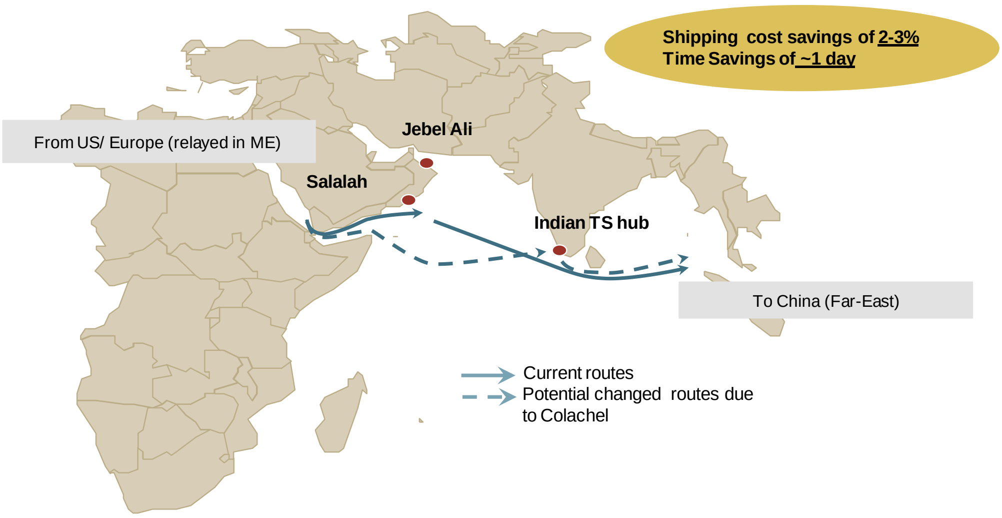


Figure 7: Potential time and cost savings for liners by using Colachel (II)

iii. Africa to Asia (Far East) traffic currently trans-shipped/ relayed in the Middle Eastern TS hub

Africa to Asia trade is expected to grow at a 6-7% rate in the next decade. Currently, most of the traffic gets relayed in Middle Eastern port cluster with the cargo arriving from China and destined to US / EU. A TS hub such as Colachel will once again be an attractive alternative as will result in voyage time saving of3-4 days and potential cost savings of 10-12% for the liners.

Africa to/ from Far East			
Current Route	**Voyage time (in days)**	**Route with Indian TS hub**	**Voyage time (in days)**
Cape Town to Salalah	13-14	Cape Town to Colachel	14-15
Salalah to Shanghai (relay)	17-18	Colachel to Shanghai (relay)	12-13
Total voyage time	**30-31**	**Total voyage time**	**27-28**

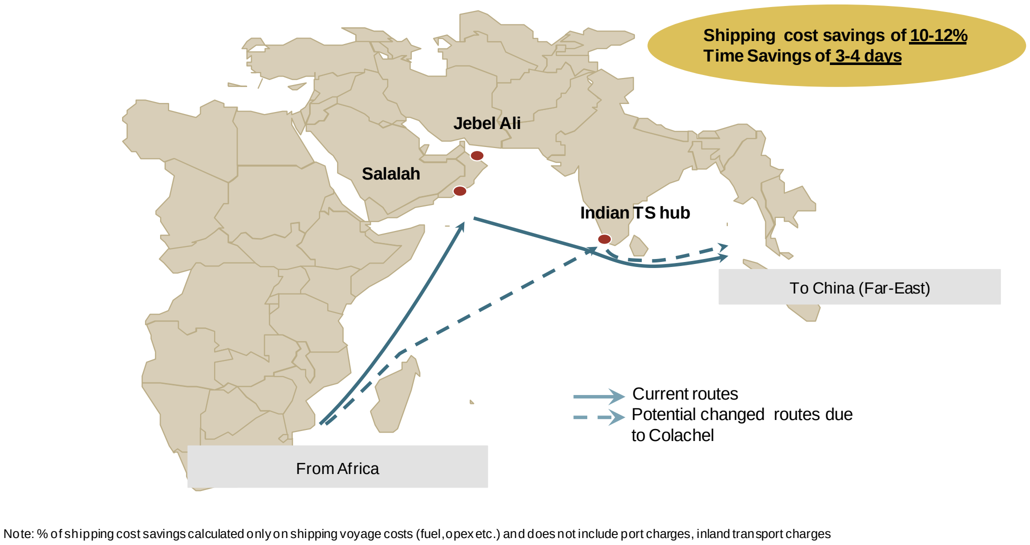


Figure 8: Potential time and cost savings for liners by using Colachel (III)

4. Mitigate risk to Indian trade due to dependence on international ports

The current scenario where 25% of the country's EXIM cargo is trans-shipped at international ports is not ideal since this makes Indian industries vulnerable to increase in costs, potential inefficiencies, congestion issues etc. at these international ports. This creates long term risks for competitiveness of India's trade and thus is another important reason for promoting a TS port in India.

2. SCOPE OF THE TEFR

The Rapid Feasibility Study was commissioned with an aim to assess the technical and financial feasibility of the proposed port. Scope of the study was laid out by the proposal document released before bidding process for the project. The TEFR is structured to cover the following aspects of the study:

- Need for the project.
- Traffic surveys and demand assessment also taking into account other Ports in the vicinity.
- Engineering surveys and investigations.
- Identify area required for development of Port, availability of land, cost, etc.
- Location and layout of the Project facility and services.
- Initial Environment Examination (IEE).
- Preliminary designs of project facility and services.
- Structuring of project including different options for developing the project.
- Schedules for modification and / or Utility Relocation Plans
- Preparation of Cost Estimates
- Establishing the Technical feasibility and Financial Viability of the Proposal
- Review and update of previous reports on Colachel Port.
- Feasibility in developing Colachel Port as a satellite port of VOCPT, considering the availability of deep draft.
- Key outputs of the rapid feasibility study – traffic, port location and port layout and the resultant financials for the port.
- Key success factors for the port Details out the planned connectivity to the port both in terms of road and railways.
- Phases the costs based on capacity phasing and construction planning.
- Projects free cash flow from the project over the years; calculates resultant IRR.

3. REVIEW OF PREVIOUS REPORTS

3.1. DETAILED FEASIBILITY STUDY ON COLACHEL PORT, INDIA (2000)

The report was prepared by Construction Industry Development Board of Malaysian Government for Tamil Nadu Government in November-2000. The report analyses the traffic and market, and proposes a port near Manavalakurichi for container traffic only.

This report gives a good approach on the container port planning. Several imputs of this feasibility study, after the due update, have been used in the current report. That is the case of the benchmarking of productivity levels for berths and cranes, key factors for the success of the port or container equipment.

Analyzing the layout, the consultant presents a well organized and protected port (although it still could have some problems with waves coming from south-east), but with some other problems like:

- A difficult and expensive dredging on rocky soil
- A river inside the basin which would generate the need for continued maintenance dredging
- Very long (around 9,000 m) and costly breakwaters
- A very high need of land acquisition both for port and industrial area
- Negative effects on local fishing industry and Indian Rare Earths Ltd as well

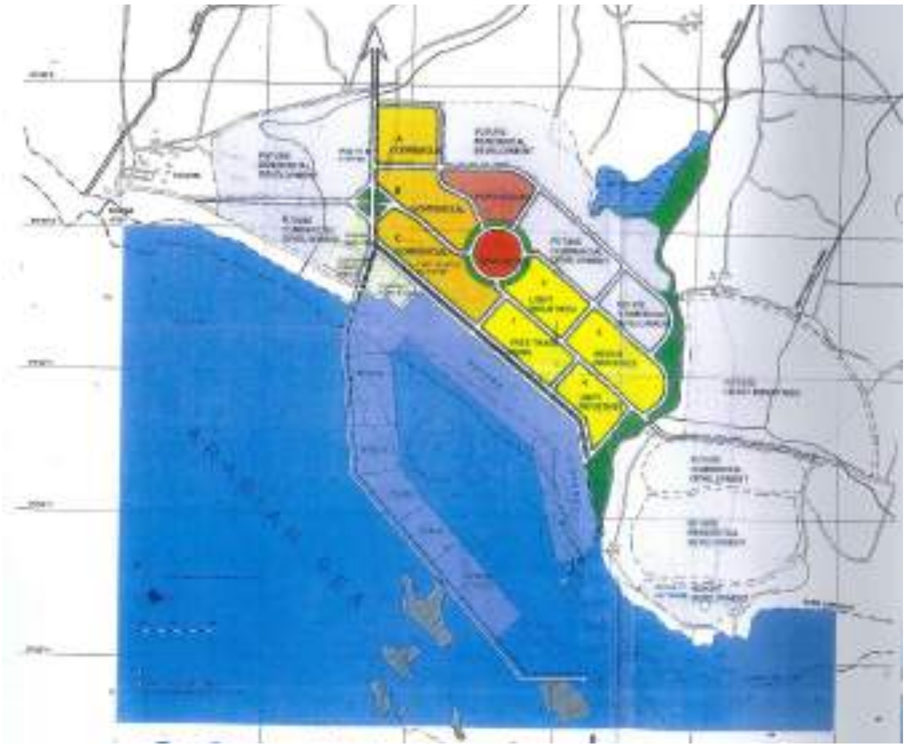


Figure 9: Caption of layout for Colachel port by Construction Industry Development Board of Malaysian Government

Inputs from the traffic and market study are not relevant for this study, since the market has changed over the last 15 years.

3.2. TECHNO ECONOMIC FEASIBILITY STUDY FOR COLACHEL PORT (2010)

This report was made by M/s i-maritime Consultancy Private Ltd. for Tamil Nadu Maritime Board (Ministry for Highways and Ports) in July 2010 and analyses the viability of establishing a multi-purpose commercial port, concluding that the port would only be viable if a captive thermal power plant is set up.

I-maritime proposes a port on the Manavalakurichi shoreline, which, from a technical point of view, has certain issues, for example:

- It is poorly protected from the swell coming from the south.
- The stocking yard of container terminals are onshore while the berths are far from them and seem too small for the expected vessels.
- The solution needs a large and difficult dredging.
- Since the port is located in the middle of a physiographic unit between Colachel and Manavalakurichi, it would have a big adverse impact to the beach dynamics and shape.
- Again, the port needs large amount of land to be acquired for terminals, which is likely to be difficult to achieve in this district.

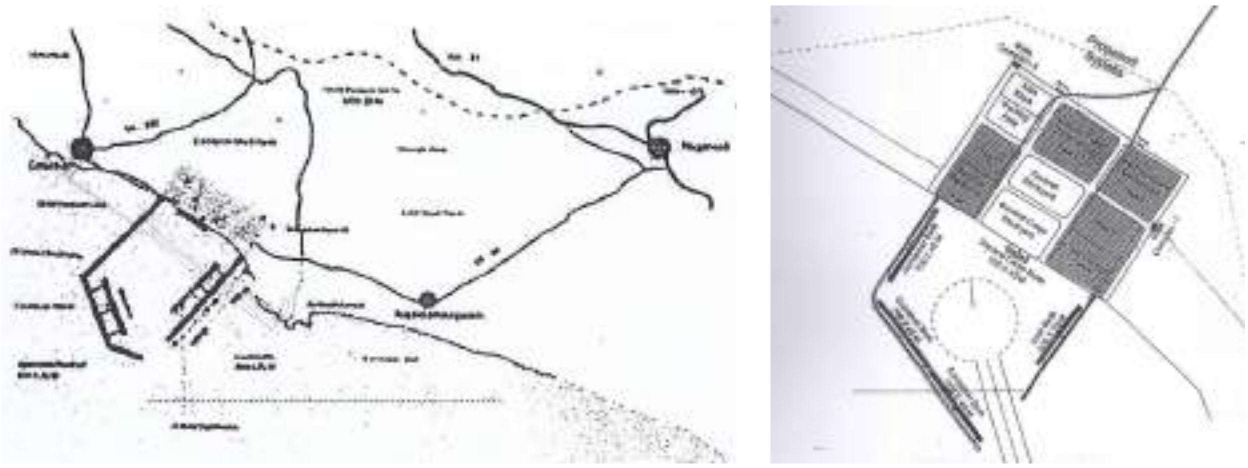


Figure 10: Location (left) and concept layout (right) for Colachel port by i-maritime Consultancy Private Ltd

Inputs have been taken on traffic and financial study from this report.

3.3. OUTER HARBOUR OF VOC PORT

M/s i-maritime Consultancy Private Ltd prepared a Detailed Project Report for the development of Outer Harbour at VOC Port in December, 2013, and a Supplementary Report adding some considerations and comments from VOCPT in October, 2014.

On February, 2015, Indian Ports Association (IPA) submitted a Report to Review and Validate the Detailed Project Report made by i-maritime. This report undertakes a detail review and proposed a new optimized layout (see figure below) and several adjustments on the design.

Figure 11: VOCPT Layout of the outer Harbour

Given, the location of the Tuticorin Port and since a draft of > 18 m cannot be achieved through the Outer harbour project, the Consultants believe that the outer harbour project cannot be developed as an alternative to Enayam. The Enayam port project should be taken up irrespective of the decision on Outer harbour project to cater to the regional container trans-shipment market.

4. KEY IMPERATIVES FOR ENAYAM PORT

The success of Enayam port depends on its ability to convince the shipping liners to re-route their traffic from the competing ports to Enayam. Liners take a long term view and consider several factors while deciding their preferred port of call.

Dipstick market test: As part of the study, the consultants have spoken with all leading shipping liners, leading Indian and International port operators and also studied in detail how other major container ports in the world have fared to understand the 'key imperatives' for Enayam. While, these key success factors have been analysed with the view of establishing a large competitive trans-shipment port, the same factors are also applicable for attracting gateway container traffic.

Basis these discussions, the following imperatives have been identified for ensuring success:

1. Deep draft
2. Proximity to main shipping routes
3. Scale of operations and sufficient capacity
4. Support and assurance of gateway traffic
5. Sufficient feeder capacity and cost efficient network
6. Competitive overall logistic economics
7. Efficient customs approval process
8. Hinterland road and rail connectivity
9. Cheap bunkering services

1. Deep Draft

The Suez route accounts for a major share of the total global container traffic flows and the mainline vessels use this route for transporting cargo between US, Europe and Asia. Nearly ~80% of India's current container trans-shipment cargo also moves through this route.

Liners prefer minimum deviation from their routes when selecting a trans-shipment port. As described in the figure below, it is clearly evident that all ports on east and west coasts of India are located at a distance of >1 day of voyage from the shipping route, which makes these locations unattractive for trans-shipment.

2. Proximity of main shipping routes

Global vessel sizes have significantly increased in the last decade and most main liner vessels have capacities of 10,000 TEUs and above, with the largest vessel reaching a capacity of 18,000 TEUs. Hence, availability of adequate draft has become an important factor in attracting shipping lines. The current Indian ports which are <1 day distance from main route have insufficient drafts to attract mainline vessels. Cochin has 14.50 m draft and Tuticorin has only 14.10 m draft. Only one terminal (CICT) has draft of 18 m (with dredging) in Colombo.

3. Scale of operation and port capacity

Shipping liners keep a long term view when deciding their preferred TS port given the costs of re-configuring existing route networks. Scale and assurance of traffic are two important factors that influence this decision. A quick scan of the successful TS ports in the region show that all of them have planned capacities of more than 10 Mn TEUs. The following figure illustrates the capacity of the ports.

In Mn TEUs	Singapore	Port Klang	Tanjung Pelepas	Colombo	Ham-bantota	Galle	Jebel Ali	Salalah	Port Abdullah
Current capacity	~32 Mn	~16 Mn	~9 Mn	~5 Mn	0	0	~15 Mn	~5 Mn	~20 Mn
Planned capacity [1]	50 Mn	30 Mn	NA	13 Mn	20 Mn	10 Mn	19 Mn	8 Mn	25 Mn

1. Planned capacity includes existing capacity
Note: Planned capacity based on announcements and press release from the port authorities; can vary significantly from actual capacity expansion implemented

Figure 12: Existing & planned capacities of TS ports

1. T/S hubs create value by aggregating cargo from small scale routes to create large parcel sizes and balance import / export traffic for long routes, and scale enables greater optimization
2. Scale also enables use of bigger feeder vessels and dedicated runs thus reducing feeder costs
3. Scales brings down overhead costs and allows port to become even more competitive on pricing
4. Scale helps set up an ecosystem around the port and helps develop the area. This then allows the port, liners and logistic companies to attract talent.

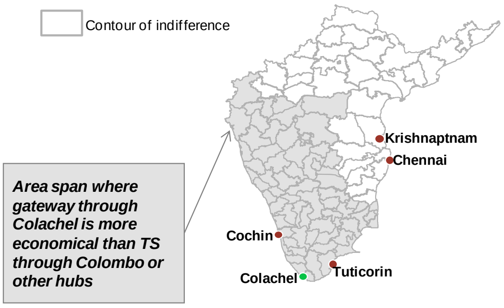
Colachel has 10 M TEUs capacity (assuming coal berth in converted to container) due to its 4km long shoreline which provides sufficient scale for the port. This capacity can be further expanded to ~18 M TEUs (post phase III of the port) by converting the breakwater into a container handling berth.

4. Assurance and support of Gateway traffic

Presence of significant assured Gateway cargo is often a big factor in liners' decision to move to a new location since it brings down the volume risk. This also becomes a key differentiator as it drives higher scale of operations for the liners and allows them to combine their gateway traffic with trans –shipment traffic without need for a feeder movement.

Colachel has high potential for gateway cargo given its proximity and access to hinterland comprising of T.N. (primary hinterland) and also parts of Kerala, Karnataka and A.P. (secondary hinterland). The hinterland currently generates 2.3 Mn TEUs of container cargo (2014). Out of this, 60% of cargo is currently trans-shipped through foreign ports. A large share of this traffic could be re-directed as gateway through Colachel given better logistic cost economics. Colachel is expected to convert upto 40-50% of the hinterland TS traffic to Gateway. The following figure illustrates the same.

Potential to convert 40-50 % of TS traffic from South Indian ports to gateway



Port in hinterland	TS cargo (in '000 TEUs)	% of TS converted to direct cargo
CHENNAI	810	20-40%
V.O. CHIDAMBARANAR	433	>90%
COCHIN	204	>90%

Note: New Mangalore not considered for analysis as there is is no TS container cargo from New Mangalore

Economic simulation: ~ 30 % cost savings for cargo from Madurai district

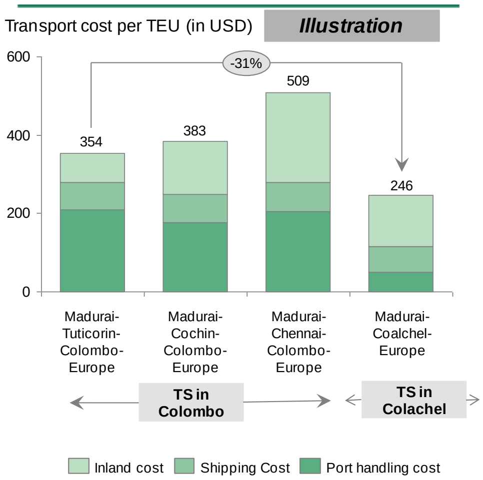


Figure 13: TS traffic converted to gateway traffic through Enayam

Cochin has limited hinterland cargo from Kerala and requires interstate transport for access to T.N. hinterland. Long delays in interstate checkpoints (e.g. delays in Walayar can be as high as 18-24 hours) have made it infeasible for T.N. exporters/ importers to use Cochin for shipping. Colombo, has limited gateway cargo and >70% of its current traffic is TS traffic. A port at Colachel would aggregate the hinterland traffic wherever logistics costs are to its favour.

5. Sufficient feeder capacity and cost efficient network

As per the traffic projections for trans-shipment traffic at Colachel Port, a feeder network with capacity of ~27,300 TEUs for a weekly service would be required in 2025. Currently, the capacity of Indian feeder network for a weekly service is ~5,100 TEUs, which is expected to grow to only ~8,300 TEUs by 2025.

Indian feeder network will only be able to serve ~30% of Colachel's demand in 2025

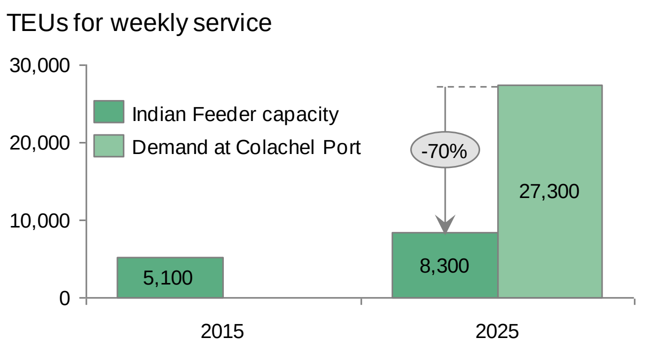


Figure 14: Indian feeder capacity available vs. requirement for Colachel

Clearly, the Indian feeder network will be insufficient to serve the needs of Colachel Port and it will be difficult to expand the capacity of Indian feeder vessels aggressively to meet requirement. This will become an important roadblock in making liners to move traffic to Colachel.

To overcome this constraint, relaxation of Cabotage law will be required to attract international feeder networks to Colachel. The most suitable option is to completely relax Cabotage for container vessel movement in India, potentially around the time when port is ready for operations. As shown in the below graph, Cabotage restriction on container vessel only serves to protect 0.6 Mn of coastal traffic as the trans-shipment traffic is anyways catered by the international feeder network even today. The other option is to relax Cabotage for Colachel specifically.

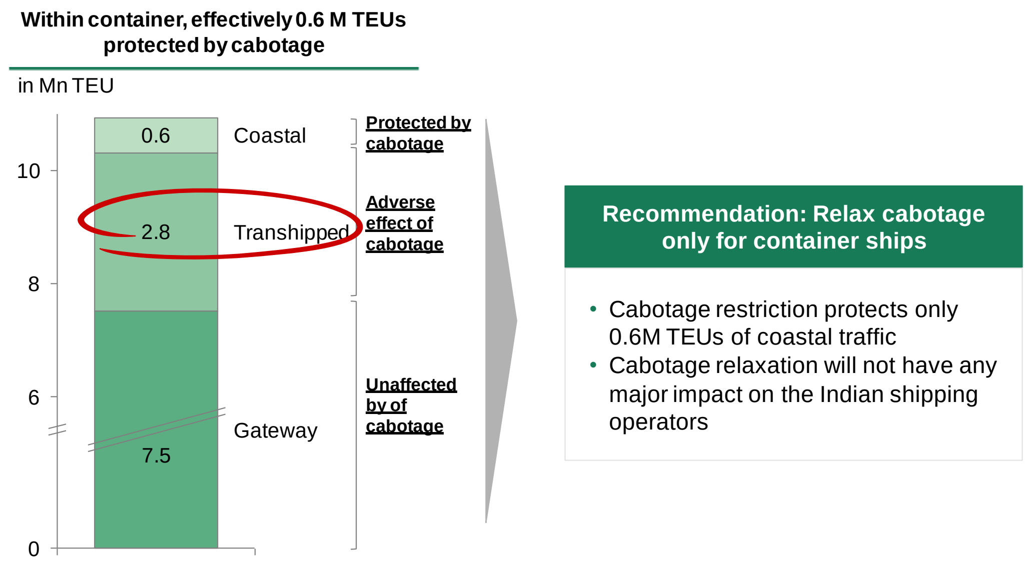


Figure 15: Cabotage relaxation for Colachel

6. Competitive overall logistics economics

The table below compares the port charges at Vallarpadam Terminal, Cochin Port with the competing Trans-shipment ports in the region.

	Vallarpadam (Cochin)	Colombo	Singapore	Klang
Vessel Related Charges - Liner	8	9	6	6
Vessel Related Charges - Feeder	5	2	2	2
Cargo handling charges	149	86	122	84
Service Tax (14%)	21	-	-	-
Total	183	97	130	92

Table 1: Comparison of Port charges for competing trans-shipment ports

The port charges at Cochin Port are ~90% higher versus Colombo Port. In order for Colachel Port to be successful in attracting traffic, it is critical to not just match the port charges with competing ports, especially Colombo Port, but also to have charges below Colombo Port for a few years. It is important to give discount over and above the port charges of Colombo Port for the following reasons:

- To make it economically viable for shipping lines to invest in capital cost of shifting existing operations (building facilities/ infrastructure for employees, office buildings etc.)
- Provide economic incentive for liners to shift and incur the cost of re-configuring their routes
- To negate the impact of 7-14% volume-based discounts at Colombo port for main lines
- To counter the cost of additional shipping time of 1-2 days for feeder traffic to east coast of India

It is recommended that a minimum discount of 15% on the port charges of Colombo Port may be given for trans-shipment traffic for a time period of 5 years to establish minimum scale of traffic in Colachel. Further, it is recommended that either the service tax may be waived off or the discount on port charges may be increased to offset the additional cost of service tax at Colachel Port.

7. Efficient customs approval process

Customs clearance process in Indian ports is perceived to be more complex and time consuming as compared to global ports; this is one of the reasons for high turnaround time and cargo lead times as in India. The following table compares the custom process and it's perception versus the competing trans-shipment ports. In terms of customer's perception of customs process India ranks a lowly 78.

Performance Indicators	Indian ports	Klang	Singapore	Jebel Ali	Colombo
Average number of documents for Import	10	4	3	5	7
Average number of documents for Export	7	4	3	3	7
Average number of signatures required for Import	27	5	3	3	10
Average number of signatures required for Import	22	3	3	3	13
Rank as per perception of customs process	78	14	1	3	72
Clearance Lead Time in days for Import	2	1	1	2	2
Clearance Lead Time in days for Export	2	1	2	2	2

Source: World Bank Study - World Development Indicators 2015

Figure 16: Comparison of customs process benchmarks

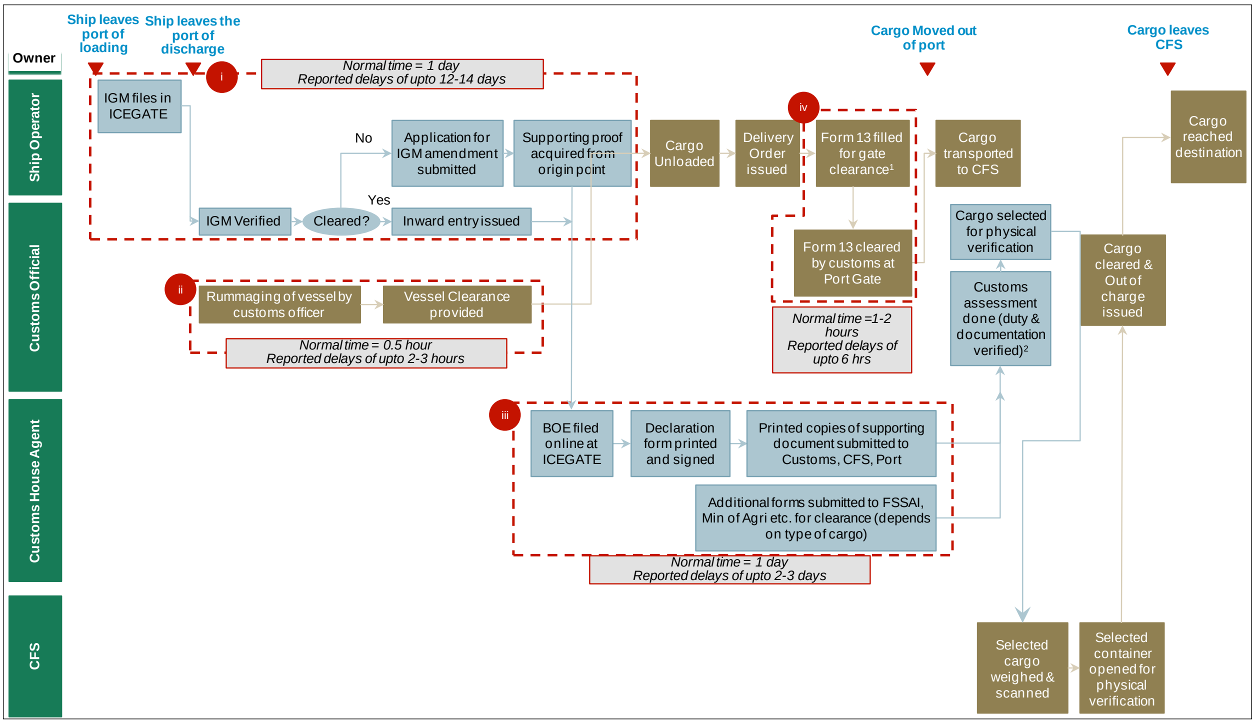


Figure 17: Cuatom process flow

Four key issues in the custom process (figure above) has been identified through discussions with customers, CFS agents, liners and port operators :

i. Complex and time consuming process for rectifying errors in IGM

- Complex form with >80 inputs and often (~10% as reported by users) results in clerical errors.
- Amendment allowed only by ship operator through a written application. The process can take upto 12-14 days and during this time the container lies stuck with port or with CFS.
- Proposed solution: Amendment process can be made simpler by allowing online applications for amendment & authorizing CHAs to make smaller amendments (correction of typographical errors)

ii. Significant documentation burden for BoE and opportunity for digitization

- BoE requires 12-15 accompanying documents and physical copies needs to be submitted to multiple agencies e.g. FSSAI, Ministy of Agriculture etc. (estimated 120 – 150 printouts required)
- Most of these forms ask for same information e.g. both packing list and invoice have data fields on consignee name, address, description of cargo (weight, dimension, quantity) etc.
- Online ICEGATE system currently has limited provisions for attaching supporting documents.
- Proposed solution: Simplify by combining and reducing number of forms/ fields required e.g. Singapore has even combined documents like invoice and packing lists. Also, develop ICEGATE into a single

window platforms for seamless sharing of information with all stakeholders e.g. Dubai Trade and the Mirsal 2 system implemented in Jebel Ali

iii. Allowing parallel loading/ unloading while vessel rummaging can save 2 – 3 hours delay

- Often, 2 – 3 hours delay occurs in loading/ unloading as the process cannot be initiated until the rummaging and clearance by custom officer. In many leading ports such Customs allow the process to start in parallel, thus avoiding the time delay.
- Proposed solution: Allow loading/ unloading of containers in parallel with rummaging process

iv. Implementation of OCR technology versus Form 13 submission process will reduce wait times at gates

- In ports where en block movement has been identified e.g. JNPT, gate movement of goods requires submission of Form 13 by CFS agent and approval by customs officer. This often leads to congestion of up to 12-18 hours at the gates.
- Use of technologies like OCR can help do away with the paper form submission process, while still allowing for tracking of vehicles & containers in and out of the port.

8. Hinterland road and rail connectivity (for gateway traffic)

Enayam (site for Colachel port) is at a distance of 11.7 km from NH 47 that connects to both T.N. and Kerala. NH 47 further connects to NH 7 which is the main arterial route and along which most of the hinterland industries are located. Developing a road connection with NH 47 has been identified as the fastest and cost efficient way of connecting the port with the hinterland.

The map below shows the existing highways and the status of their upgradation projects. NH 7 is an important corridor, which would connect the port to the hinterland industries and the Nanguneri SEZ. In order to establish connectivity with NH 7, it is vital to complete the development of the greenfield 4-lane NH-47 and the last mile connectivity to the NH-47, with the support of NHAI and State Government.

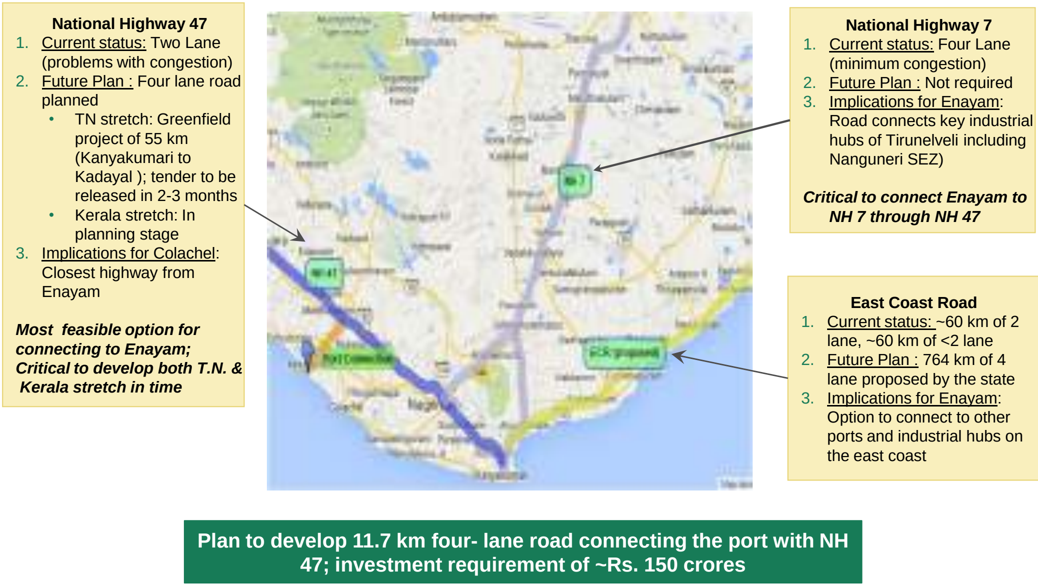


Figure 18. Road connectivity

As for rail connectivity, closest station to Enayam is Eraniel (around 10 kms off from the port site). The best option is to establish 10 km of railway track between Eraniel and Enayam to connect the port to the railway network.

The existing rail network and the ongoing rail connectivity projects are described in the map below.

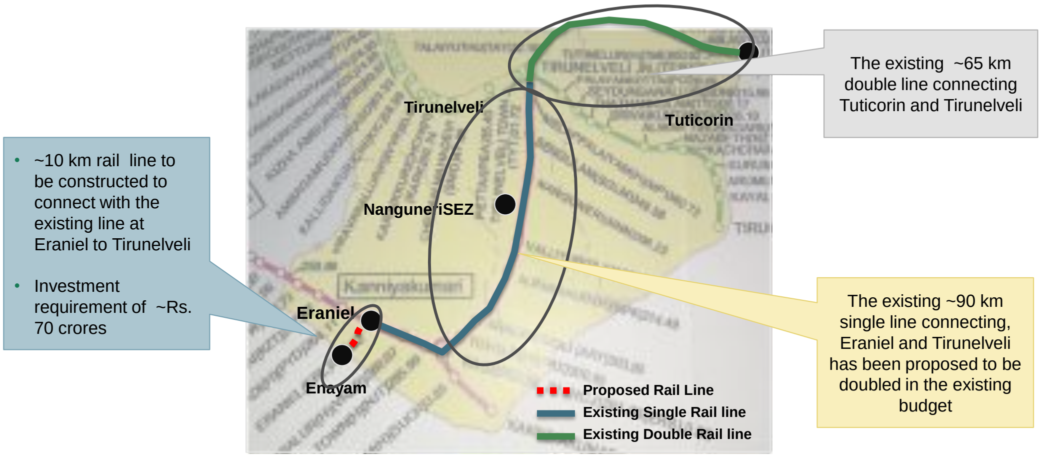


Figure 19. Rail connectivity

Connectivity to Enayam port is contingent on the following projects being completed in time before Colachel becomes operational.

1. Four laning of NH 47 – both in T.N. and in Kerala
2. Road connectivity between Enayam and NH 47 (~11.7 km road stretch)
3. Doubling of railway line between Eraniel and Tirunelveli
4. Rail connectivity between Enayam (location of Colachel port) and Eraniel (~10 km railway stretch)

Connectivity needs to be established before the port gets operationalized. This would require collaboration with all relevant authorities – Indian Railways, NHAI, State Govt., local administration along with the port administration.

9. Cheap bunker availability

Bunkering is an important cost element for liners and this can often become another factor in liners decisions to choose preferred port of call. In order to differentiate from other ports on bunkering services, it is critical to achieve high process related efficiencies (high fuel loading speeds etc.) and state of the art facilities (all weather bunkering). The industry will also need support in terms tax and duty breaks at least in the initial years. Figure below shares details on the infrastructure and tax / subsidy required for making bunkering a differentiator for the port.

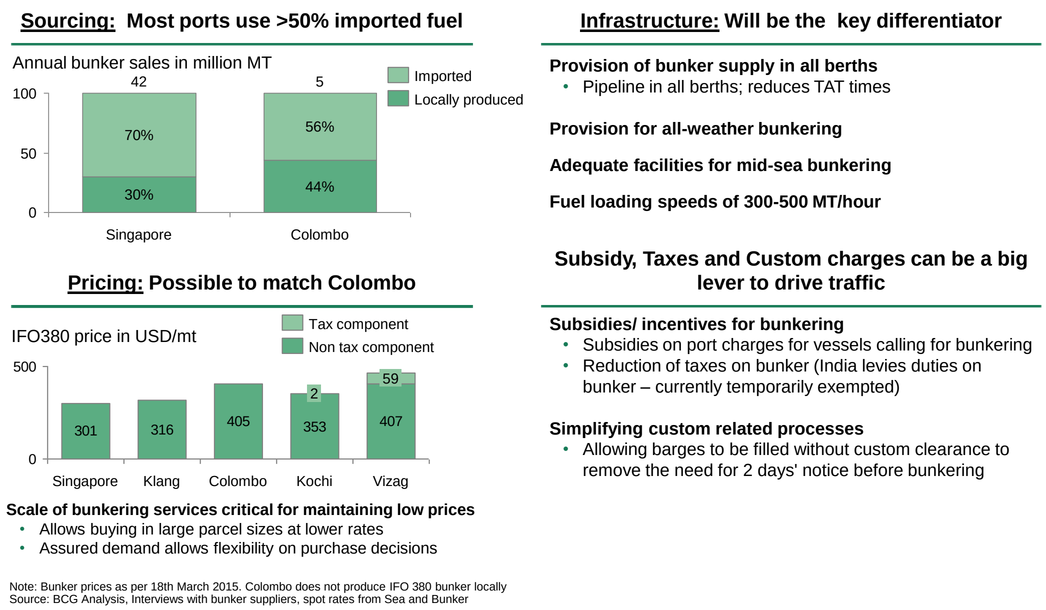


Figure 20: Requisite for competitive bunker facility

4.1. SWOT ANALYSIS OF ENAYAM PORT

An overall SWOT analysis summary for this port based on the technical and commercial study is as follows:

Strengths	Weaknesses
▪ Availability of 20 m draft ▪ Potential for gateway traffic, in addition to trans-shipment traffic ▪ Proximity to main shipping routes ▪ Large capacity (10M TEUs) and ability to expand ▪ Designed with the latest technological that will enable much higher productivity versus competing ports	▪ Existence of established ports nearby ▪ Need for greenfield infrastructure such as last mile hinterland connectivity ▪ Delays in customs procedures in India ▪ Higher taxation with respect to international ports ▪ Insufficient feeder network and higher costs
Opportunities	**Threats**
▪ Potential of in gateway traffic acceleration because of 'Make in India' campaign ▪ Growth of Africa-Asia and intra-Asia trade ▪ Development of the Indian feeder Transport System through this port	▪ Price war with Colombo Port ▪ Emergence of new ports in the region, like Hambantota ▪ Inability to attract liner as anchor investors

5. OPTIONS FOR LOCATING THE PORT

5.1. BACKGROUND

Four port locations –Kanyakumari, Manavalakurichi-Muttom, Colachel and Enayam- have been identified and analyzed from a technical, economical and environmental standpoint in order to propose the best option for locating the port.

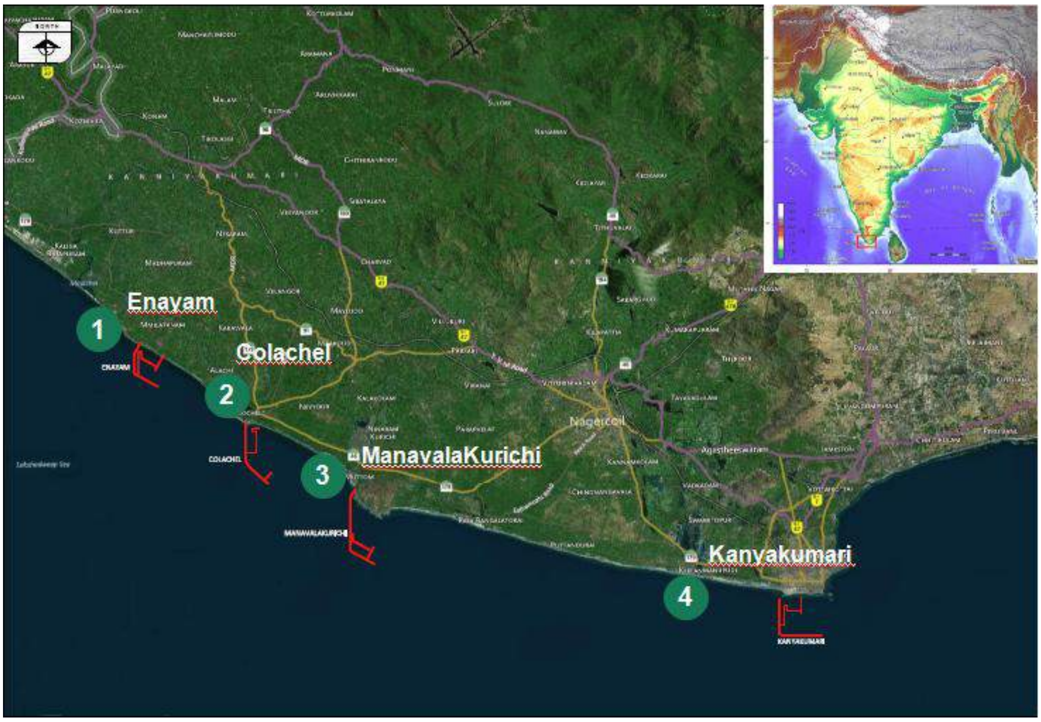


Figure 21: Proposed alternative locations and layouts

The following section contains:

- Description of the four alternative port locations, and the key advantages and disadvantages of each location.
- A general environmental description of each locations with comparative analysis
- A multi-criteria analysis to objectively select the best option for the project.

5.2. PROPOSED LOCATIONS

5.2.1. Alternative 1: Enayam

Enayam is a small fishing and agricultural village located about 8 km northwest of Colachel.

The population is concentrated near a small cape formed by a few emerged rocks. Two big beaches can be found there which serve as a stranding zone for fishing boats. These beaches rely on recently-built breakwaters which run perpendicular to the coast.

Figure 22: Area of Enayam

Going to the east of the village centre, which is the area where the port is located, the population density decreases, and the land becomes mainly occupied by coconut tree plantations and other crops.

In this section of the coast, the beaches are disappearing and moving backwards. Due to this, , some of the coconut tree plantations are disappearing and the government has built several rock walls to protect the housing near the shoreline in order to reduce the risks of tsunami.

Regarding the geometry of the seabed, the bathymetry shows that the only irregularities corresponding to rocky outcrops are off the cape mentioned above and the remaining area affected by the port infrastructure has a mild slope (softer the greater the depth) and a sandy nature. The -20.0 m depth line is about 1,500-2,000 m from the shoreline.

- Port description

The port configuration is parallel to the coast, typical of Mediterranean ports such as Genoa (Italy) Barcelona (Spain) and Marseille (France). The berths are located parallel to the coast, and protected by a breakwater which is also parallel.

The advantages of this distribution are well known in terms of terminal continuity, ease of port expansion and connectivity between terminals and land transport network.

The disadvantages are its direct impact on the shoreline, although in this case, most of the impact has been reduced by moving the port to the east.

The main breakwater is perpendicular to the prevailing south-west swell and almost parallel to the coastline at the -20.0 m depth line. The secondary breakwater, joining the coast and the main breakwater on the north-west part of the port, is designed to allow wave incidence on the beaches as much as possible -and therefore still keeping a similar coastal dynamics as the current one. The first section of this breakwater is perpendicular to the coast to gain port area without affecting significantly the dynamics.

A rubble mound breakwater is designed from the coastline to the -15.0 m depth line and a vertical breakwater when the seabed is deeper in order to optimize costs. The vertical breakwater can also be used as a berth without additional works, thus increasing port capacity.

The basin is designed with a width of 1000 meters. This distance is enough for the manoeuvring of vessels up to 400 m, the largest expected, and even if new berths were needed on the port side of the breakwater, such as liquid bulk berths.

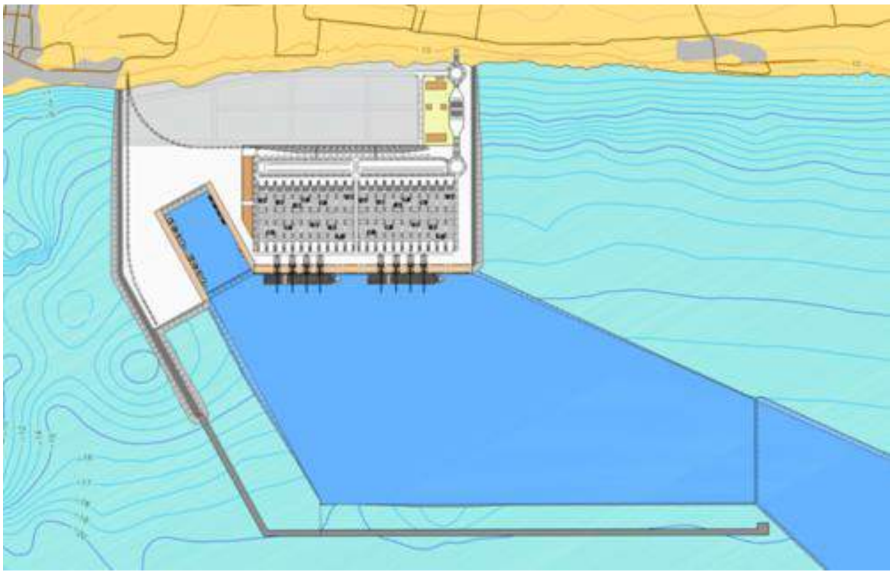


Figure 23: Enayam port layout. Phase 1

Another breakwater has been designed perpendicular to the coast on the east border of the port, both to create a barrier for the sand that can get transported to the port due to littoral drift ,and, at the same time, better protect the harbour basin.

The berths and terminal distribution for Phase 1 are as follows:

- Container Terminal: Located in the northern part of the basin, the one nearest to land, as it is the one with the best connection to the land transport network. Moreover, this position facilitates future expansions of the container terminal.
- Solid Bulk Terminals: Although coal traffic is not expected in Phase 1, the needed space has been reserved at the back of the north-south breakwater section. Since bulk transportation is expected through conveyors and loaders, the distance to land should not be a serious obstacle to the operation in future.
- Multipurpose and ancillary berths: In the most protected and shallowest part of the basin, a small 400 x 200 m basin has been designed to accommodate ancillary vessels and any other ship that can be expected in the future such as cruises, police and customs launches, navy ships, bunkering, etc.

For Phases 2 and 3, both the breakwater and the container berths are expanded towards the east of the coast. The closing breakwater is moved to the east too.

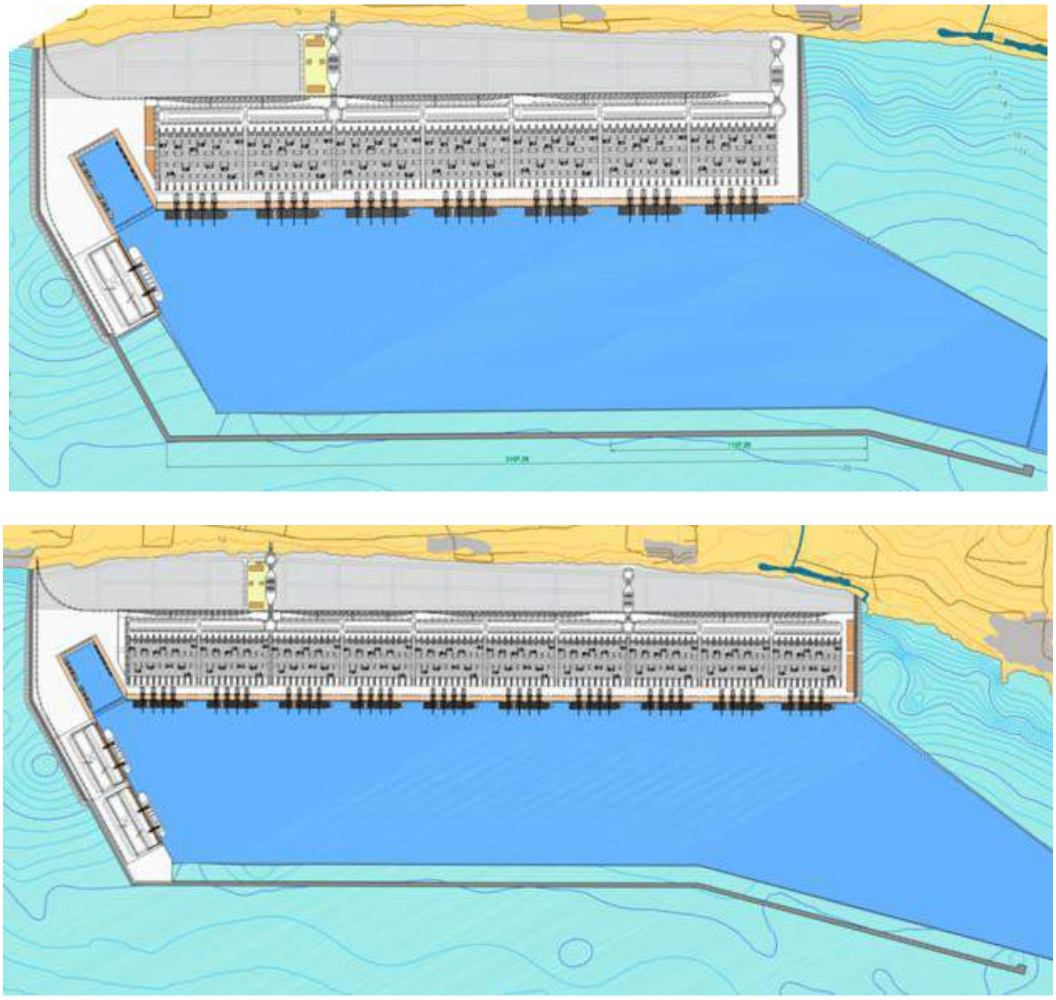


Figure 24: Phase 2 and 3 for Enayam Port

The main figures of this alternative are mentioned in the following table:

Item	Units	Phase 1 (2018-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Rubble mound breakwater	m	2,133	2,842	3,402
Vertical breakwater	m	2,506	4,395	5,502
Reclaimed land	Ha	93	249	379
Berths total lengh	m	1,400	3,800	5,400
Dredging	Cu.m	6,819,280	13,151,903	14,973,171

Table 2: Enayam port main figures (cumulative quantities)

5.2.2. Alternative 2: Colachel

Colachel is a medium-sized town, with a population of around 25,000, located approximately 8 km southeast of Enayam. Most of the people are fishermen or farmers, with a small section of traders and manufacturers.

Figure 25: Area of Colachel

The village is located near the beaches created by the breakwaters along the coast, where villagers leave their fishing boats.

At the eastern end of the village there is a small fishing port. For several years, this port was just a beach defended by a rubble mound breakwater, but it is currently being expanded to add a berth for unloading fish from medium size boats (around 15 m long) working in the area.

A small river flows into the sea about 500 m west of the fishing port. It divides the town into two parts, with some rice plantations standing in between.

Overall, the area near the village is densely populated. One has to travel 1.5 km to the east to find less populated areas.

With regard to the water area, there are some rocky outcrops around the cape and even a small chapel has been built there, but the rest of the coast is sandy. The -20.0 contour line is located approximately 2,000 or 2,500 m from the coast.

- Port description

The proposed port location is supported by the small cape on the coast and goes out toward deeper waters via a north-south oriented breakwater until reaching the -20.0 m level. Upon reaching this depth, the breakwater turns eastward to maintain the same depth until it is long enough to protect the inland waters from the southern waves.

Figure 26: Colachel port layout. Phase 1

In the first phase, the berths are located in the area closest to the shore to connect to land as quickly and easily as possible. This configuration also helps to ensure a simple future expansion of the port and avoid significant changes in the distribution of terminals as the traffic increases.

It would also be possible to begin the construction of the berths and the terminals at the deepest part of the basin, so that there is less dredging but more filling material required.

In any case, the river mouth would have to be moved slightly toward the west to stop it from interfering with the point where the port meets the coast.

For the second phase of operation, corresponding to the year 2025, it would be necessary to build 1.600 meters of berth to expand the container terminal.

In the third phase, the main breakwater would have to be extended by about 1,500 m and another 1,200 meters of berth would have to be built for containers.

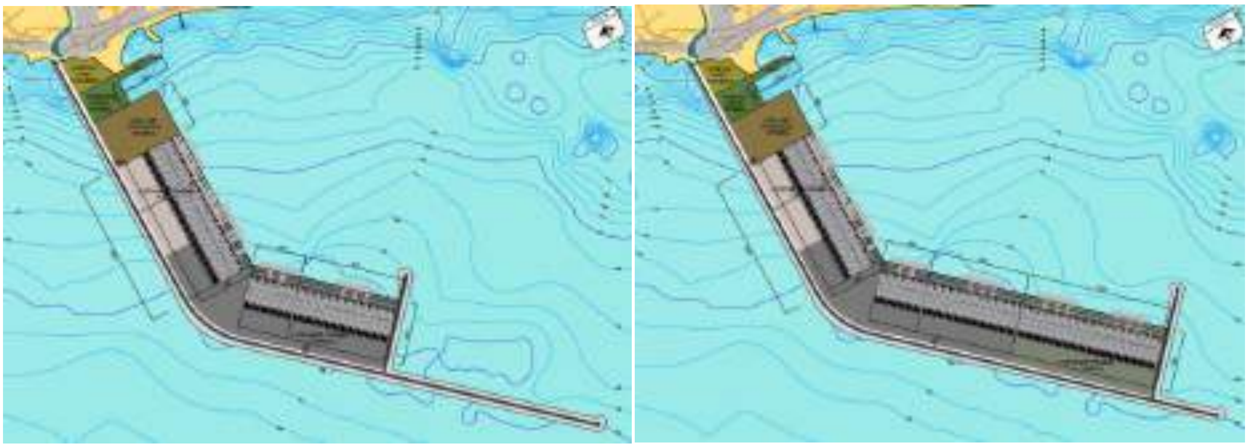


Figure 27: Colachel port layout. Phase 2 and 3

The main figures of this alternative are captured in the following table:

Item	Units	Phase 1 (2018-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Rubble mound breakwater	m	1,025	1,025	1,025
Vertical breakwater	m	3,898	5,567	6,955
Reclaimed land	Ha	929	203	272
Berths total lengh	m	1,400	3,800	5,400
Dredging	Cu.m	15,343,800	-	-

Table 3: Colachel port main figures (cumulative quantities)

5.2.3. Alternative 3: Manavalakurichi

The name of the alternative comes from Manavalakurichi, a small town located between Colachel and Muttom, where the proposed port meets the land.

Figure 28: Area of Manavalakurichi and Muttom

In addition to this population, the small towns of Kadiyapattanam and Muttom can be found on either side of the cape. There, as in the rest of the towns along this coast, most people live off fishing and agriculture.

This location features two special elements. On the one hand, the facilities of the state-owned company Indian Rare Earths Limited (IRE Ltd.), where minerals are removed from the sands of the nearby beaches through mechanical processes. The facilities are located inside Manavalakurichi, surrounded by a population cluster which has grown over the past few years. They occupy around 96 acres (40 ha) of state-owned land which could be used for port activities.

On the other side of the cape, next to Muttom, is a private fishing port called Jeppiaar Fishing Harbor. The port is for unloading and selling fish and was built through Public-Private Partnership (PPP).

In the water area, the coast is quite irregular, and there are many rocks in the vicinity that could hamper the dredging works and complicate port access navigation.

Figure 29: Washed sand stock from IRE Ltd. (left) and river mouth near Manavalakurichi

- Port description

As in the rest of the ports proposed, the main breakwater with northwest-southeast orientation is located at bathymetric level -20.0 to enable vessel access and minimize the need for maintenance dredging. To reach this depth, an offshore port has been proposed which links to land via a bridge about 1.200 m long. This typology is similar to what we can find in Shanghai's new container terminals.

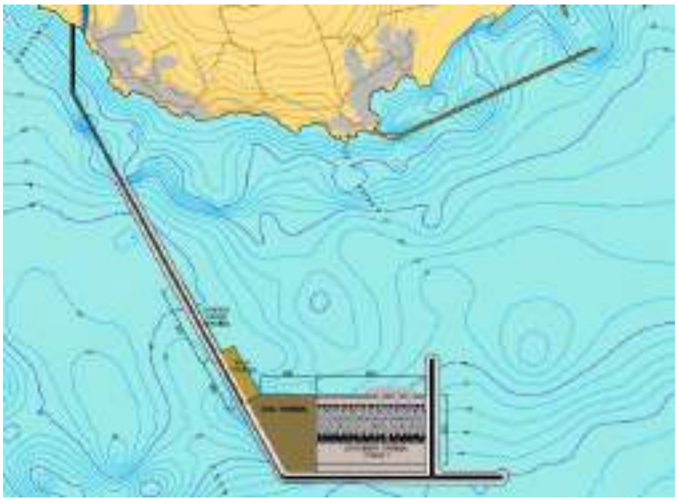


Figure 30: Manavalakurichi port layout. Phase 1

A north-south oriented slope breakwater has been designed next to the bridge to protect the berths from waves coming from the west, typical of the monsoon season.

In phase 1 of the port development, the bulk and container terminals are located in the deepest area, while the berths for auxiliary or smaller vessels are located along the slope breakwater with north-south orientation.

Phase 2, corresponding to the year 2025, requires the extension of the main breakwater toward the south-east by around 1,600 meters, and the same length for the container berth.

In Phase 3, extending the main breakwater was not considered to be an appropriate option because it would greatly affect the coastal dynamics of the beach. Therefore, the container terminal will be expanded next to the private fishing port breakwater. Even though this solution is simple and inexpensive from the maritime point of view, land accessibility would be problematic because a road link to the land side of the port would have to be built, either running through the town or surrounding the cape along the coast.

Figure 31: Manavalakurichi port layout. Phase 2 and 3

The main figures of this alternative are included in the following table:

Item	Units	Phase 1 (2018-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Rubble mound breakwater	m	1,411	1,411	2,650
Vertical breakwater	m	3,527	5,134	5,134
Reclaimed land	Ha	78.1	166	226
Berths total lengh	m	1,400	3,800	5,400
Dredging	Cu.m	12,805,900	-	-

Table 4: Manavalakurichi port main figures (cumulative quantities)

5.2.4. Alternative 4: Kanyakumari

Kanyakumari is a town of about 20,000 inhabitants which is situated at Cape Comorin, the most southern point of the Indian subcontinent.

Because of this geographical fact as well as the temples and beaches existing in the area, the city has become a tourist and pilgrimage destination within and outside India, which has led to urban, infrastructure and trade development in recent years.

The city is connected to the rest of the state by road through NH-7 motorway and the NH-47 road to Nagercoil. By rail, it is also connected to the rest of the country.

Figure 32: Area of Kanyakumari and Cape Comorin

The coast is rocky in the southern part of the city, which is where the port would be located. In fact, there are both rock outcrops east -Vivekananda Rocks, where the pilgrimage temple is located- and west, where a touristic point exists due to the views of the sunset.

In deeper water the bottom relief softens and is sandy.

- Port description

In this case the port will be just next the coastline, with an L-shaped breakwater that protects against the swell from the south and west. As in the rest of the alternatives, the breakwater reaches the -20.0 m depth line with a north-south orientation, and turns east to run parallel to the coast. In contrast, in this case the depth reached is slightly greater than 20 m, to get an easy access and maneuverability for vessels and to reduce the quantity of required dredging.

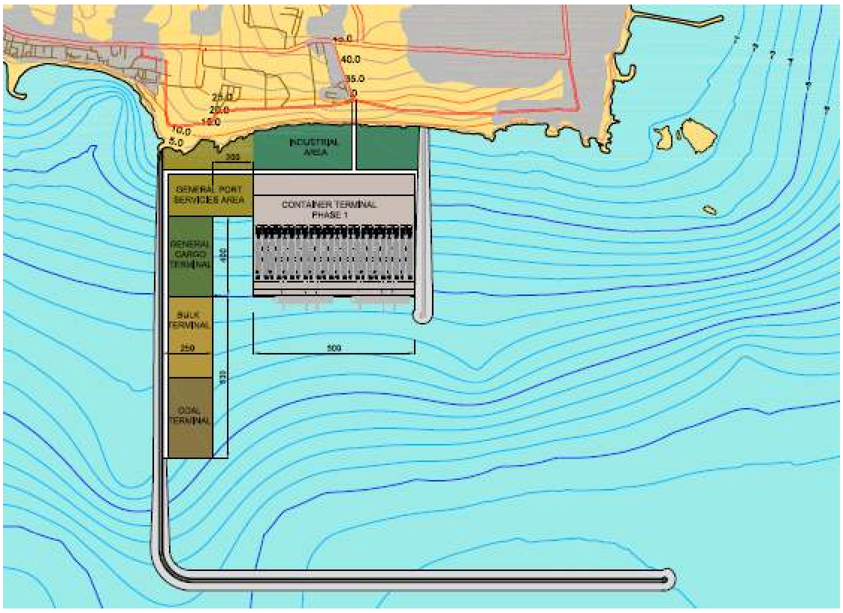


Figure 33: Kanyakumari port layout. Phase 1

In Phase 1, for the 2018 to 2020 period, the container berths are located parallel to the coast along the -10 m depth line, while solids bulk berths are placed attached to the eastern breakwater. The remaining berths are in a small basin between them.

In Phases 2 and 3, the container berth expansion runs on the back of the south breakwater. This causes building a breakwater at the eastern end of the south breakwater to protect the new berths.

Figure 34: Kanyakumari port layout. Phases 2 and 3

Main figures of this alternative are included in the following table:

Item	Units	Phase 1 (2018-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Rubble mound breakwater	m	2,760	2,760	2,975
Vertical breakwater	m	2,971	3,788	6,077
Reclaimed land	Ha	117	216	282
Berths total lengh	m	1,400	3,800	5,400
Dredging	Cu.m	7,692,000	-	-

Table 5: Kanyakumari port main figures (cumulative quantities)

5.2.5. Cost estimates

The following table shows the rough cost estimates for **Phase 1** for each alternative.

	Item	Enayam	Colachel	Manavala Kurichi	Kanyakumari
1	Preliminaries	23.63	23.63	23.63	23.63
2	Breakwaters	1,124.35	1,406.33	1,608.34	1,259.21
3	Berths	429.18	429.18	429.18	429.18
4	Dredging and Reclamation	809.12	1,145.94	943.30	824.65
5	Yards	347.29	384.64	378.76	385.83
6	Equipment	1,247.40	1,247.40	1,247.40	1,247.40
7	Buildings	27.44	27.44	27.44	27.44
8	Networks And Utilities	131.04	131.04	131.04	131.04
9	Connectivity	273.42	268.38	255.84	25.20
10	Land Acquisition	70.69	68.29	65.34	6.30
11	Others				
	Engineering And Project Management (7.5%)	336.27	384.92	383.27	326.99
	Provision For Contingencies (15%)	672.53	769.84	766.54	653.98
	Grand Total (Cr Rs.)	5,492.35	6,287.02	6,260.08	5,340.85

Table 6: Cost estimates (in Crore Rupees) for Phase 1 of all alternatives

5.3. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5.3.1. Introduction

The main objective of the environmental assessment is to undertake an environmental and social analysis of the proposed alternatives giving each alternative an environmental and social dimension.

The assessment of alternatives is based on an estimation of discriminating impacts; i.e. impacts which can distinguish between alternatives.

Hence, common or identical impacts that do not make any difference among proposed alternatives will not be included in the analysis.

The methodology used to evaluate each alternative is based on the following steps:

- Identification of main Project impacts
- Identification of synthetic impact magnitude indicators
- Alternatives assessment
- Summary of adverse impacts of each alternative

After the possible design impacts are identified, the potential environmental and social effects of every design alternative has been assessed based on the estimation of synthetic impact magnitude indicators. These impact magnitude indicators have been designed to allow discrimination between the proposed alternatives.

Such indicators are grouped according to the environmental/social element affected. The values obtained are included in an alternatives analysis where physical, biotic and social sub-factors will carry different weights.

This process assigns an environmental and social value to every alternative considered, enabling their comparison in terms of environmental and/or social impact.

Analysis of each location is developed in the Initial Environmental Examination, included as Annexure 5 of this Report. The following sections summarize the procedures and conclusions of this analysis.

5.3.2. Impacts identification and description

Impacts have been categorized into environmental and social. All these impacts have been evaluated using objective criteria and numerical values in order to facilitate the comparison among all proposed alternatives.

Environmental impacts are:

- Impacts on coastal geomorphology (sediment transport, beach dynamics) due to the new breakwaters and reclamation. Evaluation is made analyzing the quality and length of impacted shoreline.
- Impacts in Marine ecosystems due to dredging, land reclamation and port operation. Evaluation is made through the amount of dredging and land reclamation needed in each alternative.
- Impacts in Hydrology due to the increase of water supply and inland facilities (new road and railway). Assessment is made taking into account the length of inland new networks and distance to towns and villages.
- Impacts in vegetation and terrestrial ecosystems. Evaluation is made by assigning an ecological value to each type of vegetation and calculating the possible area that will likely get altered by the new port.

Social impacts can be summarized as follows:

- Impacts on transport networks (roads) due to material transport during construction. Road length and villages crossed by them are the criteria to asses this impact.
- Impacts on land ownership and displacement of people. The total population that could be affected by the new port has been estimated for each port location.
- Impacts on fisheries due to construction works, occupation of shoreline and port activities. This impact has been evaluated by counting the boats that would be relocated by each port.
- Impacts on tourism. A qualitative criteria has been used taking into account the resorts and touristic places of each location.
- Impacts on coastal planning. The Coastal Zone Management Plan of Tamil Nadu has been used to evaluate the sensitive areas that could be impacted by the new ports.

Further information regarding description and assessment of impacts is included in Section 4.3 of Initial Environmental Evaluation (Annexure 5 to this Report).

5.3.3. Impacts evaluation

Impacts evaluation study, evaluation criteria and detailed description of each ones are included Annexure 6. A brief summary is presented here.

5.3.3.1. Gross impacts evaluation

The following table summarizes the estimated adverse impacts on each alternative.

Estimated adverse impacts on each alternative						
Factors	**Sub-factor**	**Adverse Impact**	**Estimated Impact score**			
			Alternatives			
			1 Enayam	**2 Colachel**	**3 Manavala kurichi**	**4 Kanyakumari**
Coastal geomor - phology	Sediment transport, beach dynamics	Changes in erosion and accretion patterns along the coast	78,8	84,8	35,5	48,1
Marine ecosystems	Marine water quality	Increase in turbidity. Change in marine water quality due to aqueous discharges	6230070	15343819	12805893	7692053
	Marine ecology	Removal of benthic communities. Decrease in species diversity				
Hydrology	Water resources	Impact on existing water resources, specially ground water, scarcity	50	100	70	100
	Drainage network	Disturbance to natural drainage pattern due to road widening	13,5	11,6	14	3,5
Vegetation/ terrestrial ecosystems	Vegetation/ land cover	Loss of agricultural land. Loss of natural vegetation,	46808,3	44835,5	46615,5	29358,5
Socio - economic	Road network	Strain on existing infrastructure	50	60	75	20
	Land ownership	Properties loss, displacement of people	2130	6146	2908	4264
	Fisheries	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	1170	1557	1145	881
	Tourism	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	10	70	40	100
	Coastal Planning	Impact on CRZ-I areas	0	70	0	100

Table 7: Estimated adverse impacts on each alternative

5.3.3.2. Sensitivity analysis

With these values, we proceed to achieve a global impact magnitude value for each of the alternatives. That alternative scoring a lesser gross-magnitude impact value would be the better in terms of environmental and social feasibility.

To obtain that final impact value for each of the alternatives, based on different *weightings* of the estimated impacts values, we considered three different scenarios in order to evaluate the performance of the alternatives in each of them. These are the following:

- Environmental and social factors weight the same. 50%-50%
- All the environmental and social sub-factors weigh the same, i.e. all the adverse impacts weight the same.
- A different weight is given to factors and sub-factors, i.e. to the adverse impacts, based on an expert judgement.

To carry out this sensitivity analysis, first we proceed to normalize (homogenization) the impact values, converting them into a 0-100 range, the highest value corresponding to the negative impact of greater magnitude and therefore the lower valuation of the alternative. The results of the homogeneous evaluation are showed in the following table:

Estimated impact ranged to a 0-100 interval						
Factors	**Sub-factor**	**Adverse Impact**	**Estimated Impact score**			
			Alternatives			
			1 Enayam	**2 Colachel**	**3 Manavala kurichi**	**4 Kanyakum ari**
Coastal geomor - phology	Sediment transport, beach dynamics	Changes in erosion and accretion patterns along the coast	92,9	100,0	41,9	56,7
Marine ecosystems	Marine water quality	Increase in turbidity. Change in marine water quality due to aqueous discharges	40,6	100,0	83,5	50,1
	Marine ecology	Removal of benthic communities. Decrease in species diversity				
Hydrology	Water resources	Impact on existing water resources, specially ground water, scarcity	50,0	100,0	70,0	100,0
	Drainage network	Disturbance to natural drainage pattern due to road widening	96,4	82,9	100,0	25,0
Vegetation/ terrestrial ecosystems	Vegetation/ land cover	Loss of agricultural land. Loss of natural vegetation,	100,0	95,8	99,6	62,7
Socio - economic	Road network	Strain on existing infrastructure	66,7	80,0	100,0	26,7
	Land ownership	Properties loss, displacement of people	34,7	100,0	47,3	69,4
	Fisheries	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	75,1	100,0	73,5	56,6
	Tourism	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	10,0	70,0	40,0	100,0
	Coastal Planning	Impact on CRZ-I areas	0,0	70,0	0,0	100,0

Table 8. Estimated adverse impacts valuation per alternative - Homogeneous evaluation

For the sensitivity analysis I, all the factors are equally weighted (0.5) and the impact scored is calculated. The results are as follows:

Sensitivity analysis 1: Environmental and social factors weigh the same. 50%-50%								
Factors		Sub-Factors		Adverse Impact	Estimated Impact score			
					Alternatives			
	Weights		Weights		1 Enayam	2 Colachel	3 Manavala kurichi	4 Kanyakumari
Coastal geomor - phology	0,5	Sediment transport, beach dynamics	0,125	Changes in erosion and accretion patterns along the coast	11,6	12,5	5,2	7,1
Marine ecosystems		Marine water quality	0,125	Increase in turbidity. Change in marine water quality due to aqueous discharges	5,1	12,5	10,4	6,3
		Marine ecology		Removal of benthic communities. Decrease in species diversity	0,0	0,0	0,0	0,0
Hydrology		Water resources	0,062	Impact on existing water resources, specially ground water, scarcity	3,1	6,3	4,4	6,3
		Drainage network	0,063	Disturbance to natural drainage pattern due to road widening	6,0	5,2	6,3	1,6
Vegetation/ terrestrial ecosystems		Vegetation/ land cover	0,125	Loss of agricultural land. Loss of natural vegetation.	12,5	12,0	12,4	7,8
Socio - economic	0,5	Road network	0,100	Strain on existing infrastructure	6,7	8,0	10,0	2,7
		Land ownership	0,100	Properties loss, displacement of people	3,5	10,0	4,7	6,9
		Fisheries	0,100	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	7,5	10,0	7,4	5,7
		Tourism	0,100	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	1,0	7,0	4,0	10,0
		Coastal Planning	0,100	Impact on CRZ-I areas	0,0	7,0	0,0	10,0
					67,0	**90,4**	**64,8**	**64,3**

Table 9. Estimated adverse impacts valuation per alternative - Sensitivity analysis I

For the sensitivity analysis II, all the sub-factors (11) are equally weighted (0.09). The results are as follows

Sensitivity analysis 2: All the environmental and social sub-factors weigh the same							
Factors	**Sub-factor**		**Adverse Impact**	**Estimated Impact score**			
				Alternatives			
		weights		**1 Enayam**	**2 Colachel**	**3 Manavala kurichi**	**4 Kanyakum ari**
Coastal geomor - phology	Sediment transport, beach dynamics	0,09	Changes in erosion and accretion patterns along the coast	8,4	9,0	3,8	5,1
Marine ecosystems	Marine water quality	0,09	Increase in turbidity. Change in marine water quality due to aqueous discharges	3,7	9,0	7,5	4,5
	Marine ecology	0,09	Removal of benthic communities. Decrease in species diversity	0,0	0,0	0,0	0,0
Hydrology	Water resources	0,09	Impact on existing water resources, specially ground water, scarcity	4,5	9,0	6,3	9,0
	Drainage network	0,09	Disturbance to natural drainage pattern due to road widening	8,7	7,5	9,0	2,3
Vegetation/ terrestrial ecosystems	Vegetation/ land cover	0,09	Loss of agricultural land. Loss of natural vegetation,	9,0	8,6	9,0	5,6
Socio - economic	Road network	0,09	Strain on existing infrastructure	6,0	7,2	9,0	2,4
	Land ownership	0,09	Properties loss, displacement of people	3,1	9,0	4,3	6,2
	Fisheries	0,09	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	6,8	9,0	6,6	5,1
	Tourism	0,09	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	0,9	6,3	3,6	9,0
	Coastal Planning	0,09	Impact on CRZ-I areas	0,0	6,3	0,0	9,0
			TOTAL	**51,0**	**80,9**	**59,0**	**58,2**

Table 10. Estimated adverse impacts valuation per alternative - Sensitivity analysis II

For the sensitivity analysis III, all factors and sub-factors are equally weighted by the 3 environmental expert criteria, resulting from the previous impact analysis and experience. The results are as follows:

Sensitivity analysis 3: Expert judgement								
Factors		**Sub-factor**		**Adverse impact**	**Estimated Impact score**			
					Alternatives			
	weights		**weights**		**1 Enayam**	**2 Colachel**	**3 Manavala kurichi**	**4 Kanyakum ari**
Coastal geomor - phology	0,2	Sediment transport, beach dynamics	0,2	Changes in erosion and accretion patterns along the coast	13,9	15,0	6,3	8,5
Marine ecosystems	0,15	Marine water quality	0,15	Increase in turbidity. Change in marine water quality due to aqueous discharges	8,1	20,0	16,7	10,0
		Marine ecology	0	Removal of benthic communities. Decrease in species diversity				
Hydrology	0,1	Water resources	0,05	Impact on existing water resources, specially ground water, scarcity	2,5	5,0	3,5	5,0
		Drainage network	0,05	Disturbance to natural drainage pattern due to road widening	4,8	4,1	5,0	1,3
Vegetation/ terrestrial ecosystems	0,2	Vegetation/ land cover	0,2	Loss of agricultural land. Loss of natural vegetation.	15,0	14,4	14,9	9,4
Socio - economic	0,35	Road network	0,04	Strain on existing infrastructure	3,3	4,0	5,0	1,3
		Land ownership	0,07	Properties loss, displacement of people	3,5	10,0	4,7	6,9
		Fisheries	0,1	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	7,5	10,0	7,4	5,7
		Tourism	0,07	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	1,0	7,0	4,0	10,0
		Coastal Planning	0,07	Impact on CRZ-I areas	0,0	3,5	0,0	5,0
				TOTAL	**59,7**	**93,0**	**67,5**	**63,1**

Table 11. Estimated adverse impacts valuation per alternative - Sensitivity analysis III

The following table and figure summarize the results that express a ***global impact magnitude*** of the impact of each of the alternatives considered. Again, the higher the value obtained the bigger the magnitude of the global negative impact. The best alternative is, therefore, that one with a lower score.

Analysis	Estimated Impact score			
	Alternatives			
	1. Enayam	2. Colachel	3. Manavalakurichi	4. Kanyakumari
All the factors weight the same	51.0	80.9	59.0	58.2
Environmental and social factors weights the same	57.0	90.4	64.8	64.3
Expert judgement.	59.7	93/0	67.5	63.1
Average value	55.9	88.1	63.8	61.9

Table 12: Total estimated adverse impacts score per alternative

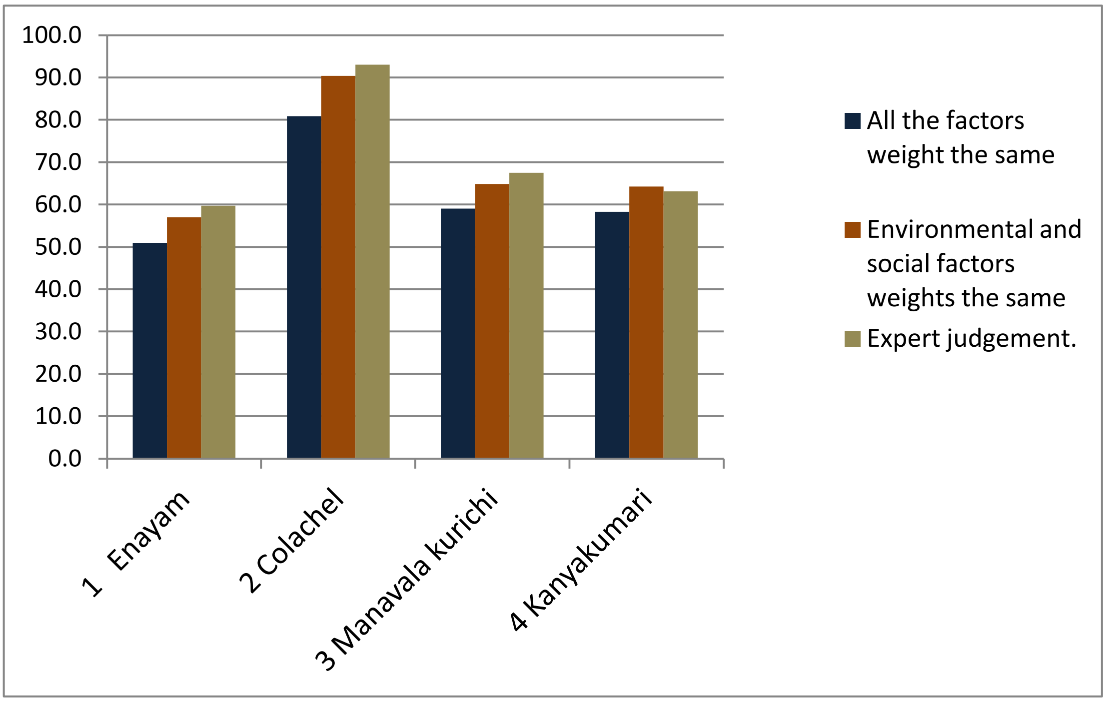


Figure 35: Results from the Sensitivity analysis

5.3.4. Conclusions on environmental impact

The best rated alternative for location, with the lowest environmental and social impact, is Enayam, while the worst rated one, with the highest impact, is Colachel. Kanyakumari and Manavalakurichi obtained similar intermediate ratings. The Enayam location has lower environmental impacts than the others with respect to dredging, cultural sites and its low impact on property due to its low population. Port expansion will not need a wide extra inland area since the land reclamation area will provide room for port facilities and industries.

The Manavalakurichi location has lower environmental impacts than Kanyakumari with respect to, tourism and cultural sites. Manavalakurichi has lower environmental impacts than Enayam with respect to coastline and fishing. This is due to its special configuration whereby the port is not attached to the coastline and connects inland via a bridge that allows the transport of sediments and therefore has a lower effect on coastal processes. Its inland population density which could be affected by the expansion of the port is lower than in Colachel and Kanyakumari.

The Kanyakumari location was better rated in regards to its proximity to the transport network and because the coastline is more poorly preserved. In any case, a more in-depth weighting of the touristic and cultural factor would rule out this option.

The Colachel location is the worst rated due to its possible impact on the surrounding beaches, which are in a suitable state of preservation and where there is fishing. The beach located to the east of the port location would become a pocket beach, retaining its sand and quality, but would be disconnected from the natural coastal dynamics. In addition, the port is located right next to the heritage town of Colachel, with a dense population and therefore with the potential to impact on underground water resources.

5.4. SELECTION CRITERIA AND SELECTED OPTION

Even though the alternatives have been designed to provide a similar operational capacity, their location and environmental conditions lead to differences between them. These differences will be assessed based on the following criteria:

To compare and select the best of the four proposed options, a series of criteria have been defined to assess them realistically.

These criteria could be classified into the following categories:

- Functionality criteria
- Construction and expansion criteria
- Connectivity criteria
- Environmental criteria, which includes:
  i. Environmental impact
  ii. Social Impact

Other criteria like construction costs and maintenance costs have been evaluated.

The table below is the result of applying these criteria to each option:

	Enayam	Colachel	Manavalakurichi	Kanyakumari
Population Density	Low	Very high	High	Very high
Accessibility & manoeuvrability	Good vessel operability	High vessel operability	High vessel operability	Good vessel operability
Expandability	Easy to expand, even beyond phase 3	Difficult to expand	Difficult to expand	Easy to expand
Environmental & social impact	Low impact	High impact	Medium impact	Medium impact
Land availability	Higher possibility of land acquisition	Lower possibility of land acquisition	Lower possibility of land acquisition *(possibility of acquiring ¬100 acre of IRE land)*	Lower possibility of land acquisition
Impact of tourism and housing	Low impact; shoreline free of houses	High impact on housing	High impact on housing	High impact on tourism
Hinterland Connectivity	Longer distance to NH -7 and rail line	Longer distance to NH -7 and rail line	Longer distance to NH -7 and rail line	Best connectivity to NH 7 and rail line

Table 13: Qualitative assessment of alternatives

Besides, a numerical comparison has been made to be sure of the selection. All assessments lead to the conclusion that **Enayam is the best option** of the four to develop a port in this area of Tamil Nadu.

6. TRAFFIC AND MARKET STUDY

6.1. APPROACH

A detailed traffic modelling and analysis has been conducted to arrive at the traffic estimates for the port. Based on the overall analysis of the current traffic, it has been assessed that the principal commodities that contribute to majority of the cargo volumes in the region are: POL (petroleum, oil and lubricants), Container and Coal.

Hence, this traffic study has been further detailed out for these three principal commodities.

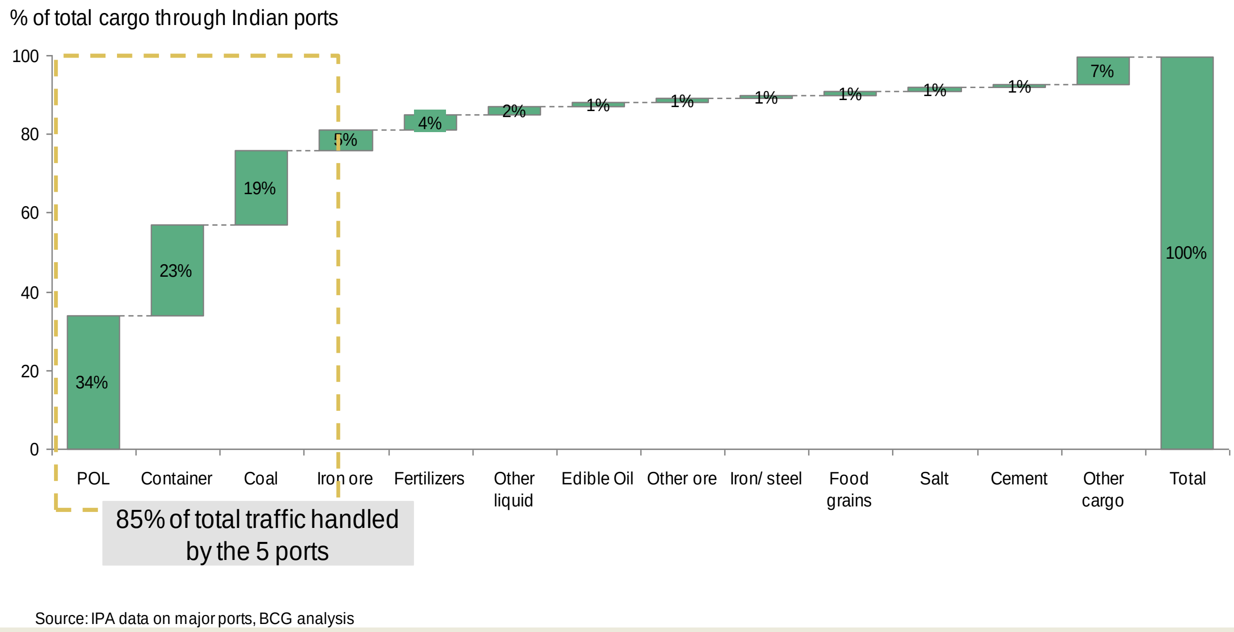
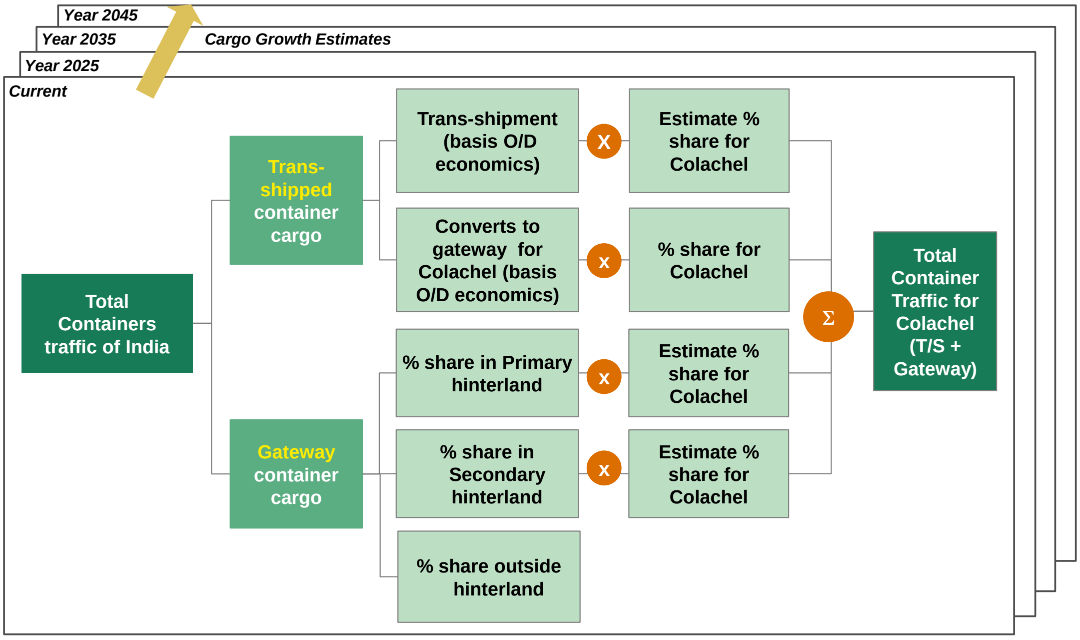


Figure 36: Commodity wise cargo split from Indian ports

Further, the container traffic has been studied in detail in two categories: trans-shipment traffic and gateway separately, keeping in mind that the one of the key objectives of this port project is target and gain back share of the Indian container cargo being trans-shipped outside India.

A comprehensive study has been undertaken for container traffic forecasts. The detailed methodology followed for container traffic forecast has been summarised below:



Coal traffic projections have been undertaken based on the detailed analysis of the region. The key steps in the methodology for coal traffic forecast have been summarized below:

1. Power demand-supply gap for Tamil Nadu estimated by mapping all announced power plant plans and projecting future power demand in the state
2. Feasibility of Enayam as a location, to cater to already planned power plants
3. Feasibility and timing for setting a new captive power plant for Enayam has been evaluated

In order to assess the POL traffic, the methodology followed focuses on the feasibility of Enayam for catering to any planned petroleum refineries in the country.

6.2. TRAFFIC PROJECTIONS

6.2.1. Container traffic projections

Containers are expected to be the key traffic drivers for Enayam port. Enayam has been proposed with the aim to capture traffic that today gets transported through Colombo and other trans-shipment hubs. This section projects container traffic for Enayam. First, an overall view of India's container traffic flow is built and India's container traffic is projected based on key traffic growth drivers. Then, hinterland for Enayam is identified; the existing industries in the hinterland are studied and potential industrialization is explored. Finally, Enayam's share of both trans-shipment and gateway traffic has been estimated.

6.2.1.1. India container projections

<u>Indian container flow</u>

Indian ports at present handle ~11Mn TEUs of container traffic every year and around 95% of this traffic is from EXIM trade. The following figure shows route wise volume of container traded to and from India. China and Far East countries rank 1st on volumes of container traded with India accounting for around 2.7 Mn TEUs of India based container traffic. China is followed by North America (east and west costs), Middle East, Europe and S.E.Asia as primary origin or/and destination of India based container cargo.

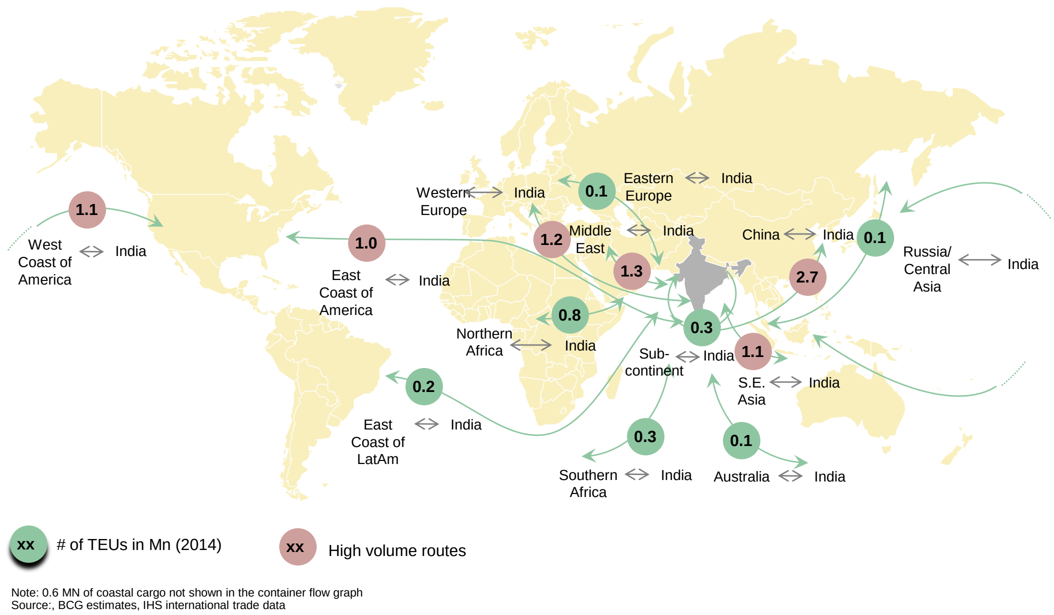


Figure 37: Trade route wise split of container traffic

Around 7.5 Mn TEUs of container cargo is directly shipped to Indian ports from the origin ports. Cargo to/from China is almost entirely direct Gateway cargo which today comes to JNPT, Mundra and other Indian ports. Similarly cargo to Middle East, Africa, and S.E.Asia are also direct gateway traffic.

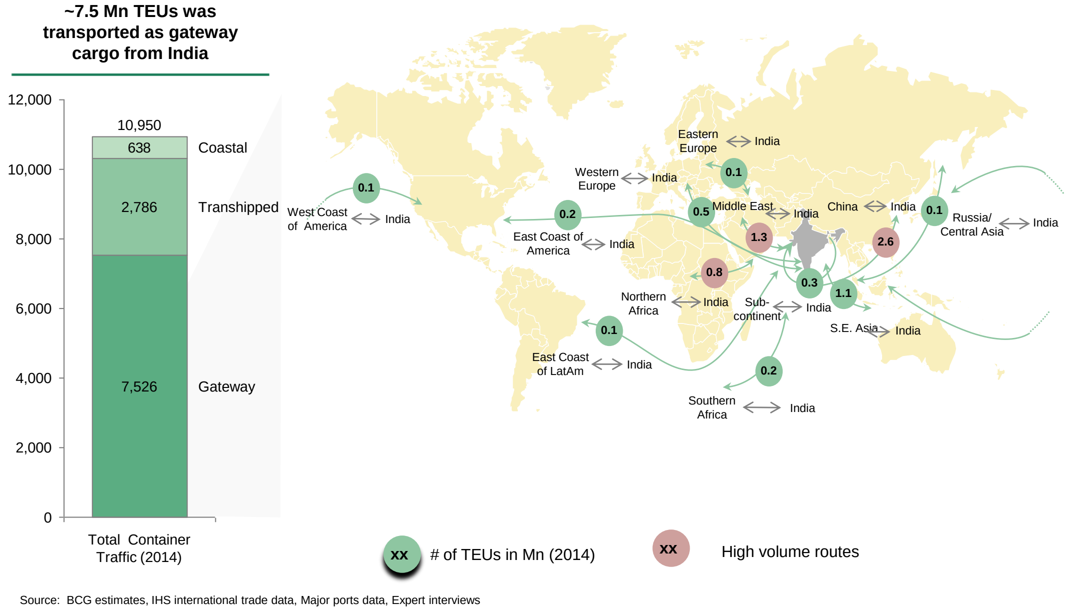


Figure 38: Route wise split of gateway cargo

~2.8 Mn TEUs of container cargo for India gets trans-shipped in trans-shipment hubs. Based on analysis of global container traffic, there are three primary routes that sees a high proportion of trans-shipment – India to Europe, India to East Coast of America and India to West Coast of America. The following figure details out route wise volume of trans-shipped cargo. All volumes mentioned are single counted.

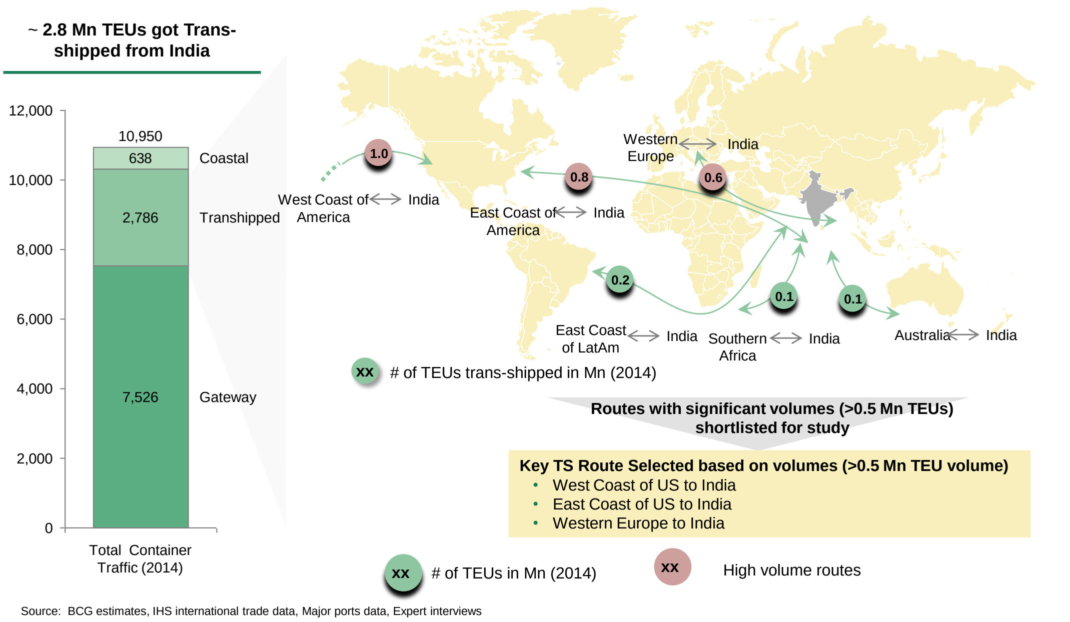


Figure 39: Route wise split of trans-shipment cargo

India today does not have any large trans-shipment hub ports. Most of the trans-shipment of Indian cargo happens in foreign trans-shipment hubs. Colombo alone handles around 1.2 Mn TEUs of India's trans-shipment cargo, while Colombo, Singapore and Klang together account for ~80% of India's trans-shipment cargo. Other trans-shipment hubs for India include Jebel Ali, Dubai, and Salalah. Among the Indian ports, majority of trans-shipment happens from East Coast ports of Tuticorin, Chennai, and Kolkata. The following figure gives a detailed trans-shipment hub wise breakup of Indian container cargo.

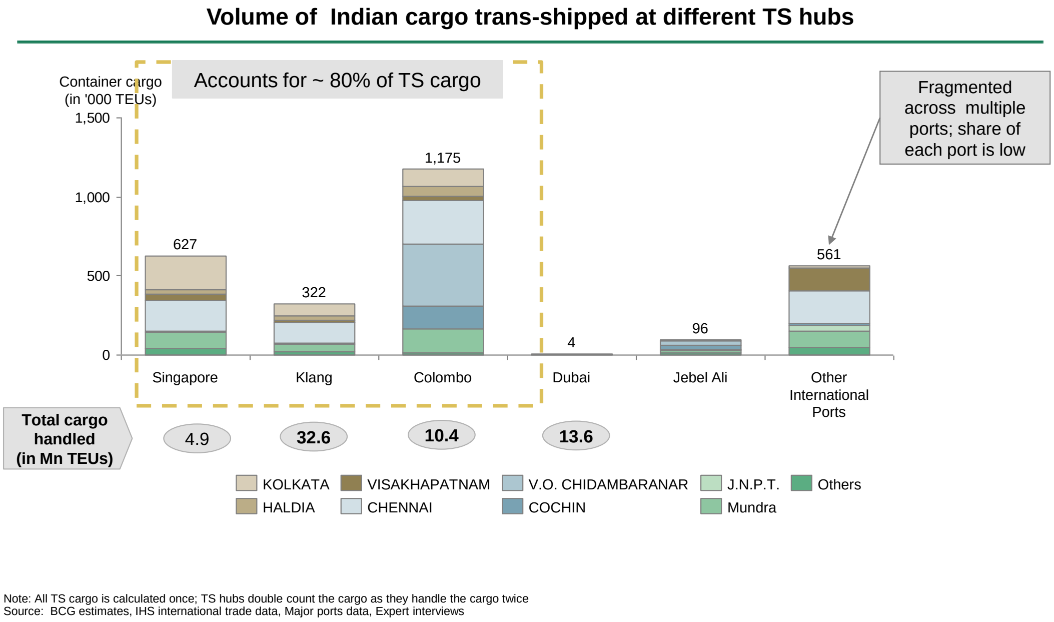


Figure 40: Key trans-shipment hubs for Indian container cargo

Projections of Indian Container Cargo

Container cargo volumes for any country are a direct function of imports and exports of the country which in turn is driven by manufacturing industries and consumption demand in the country. GDP is a proxy for both manufacturing industry and consumption. As seen in the next figure, GDP is highly correlated with the container traffic volumes and hence, is a reliable indicator of container traffic.

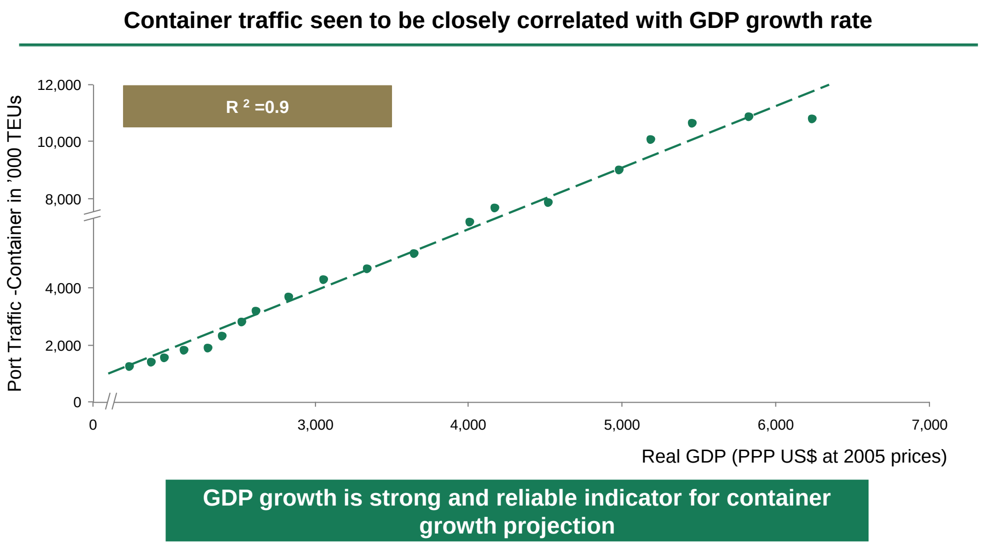


Figure 41: Correlation between GDP and container volumes

Historical trends for container traffic volume shows that container traffic outgrows GDP growth. The reason of higher container traffic growth is due to three key factors, as described in the figure below:

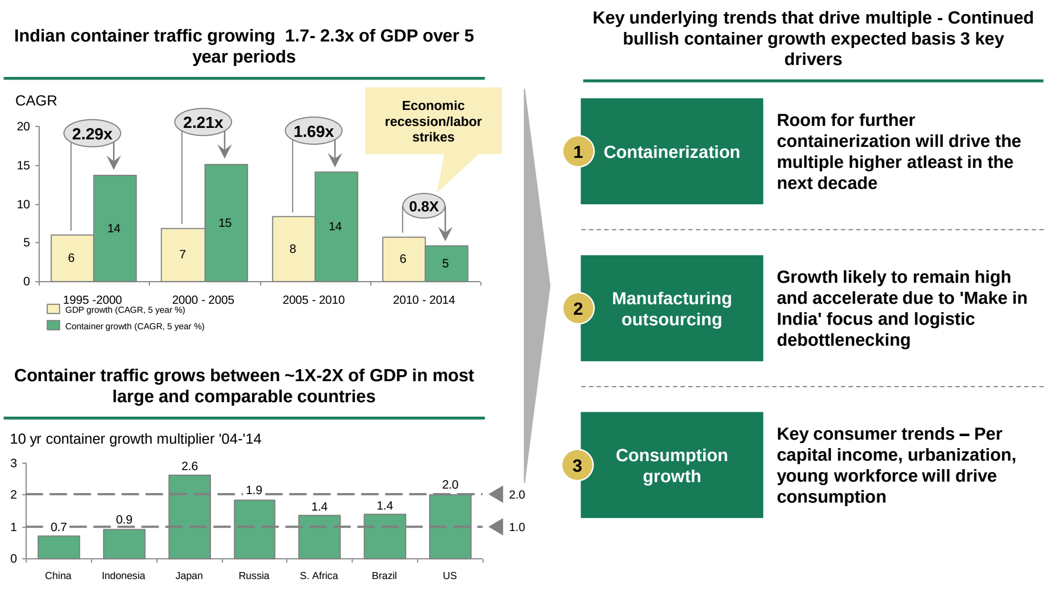
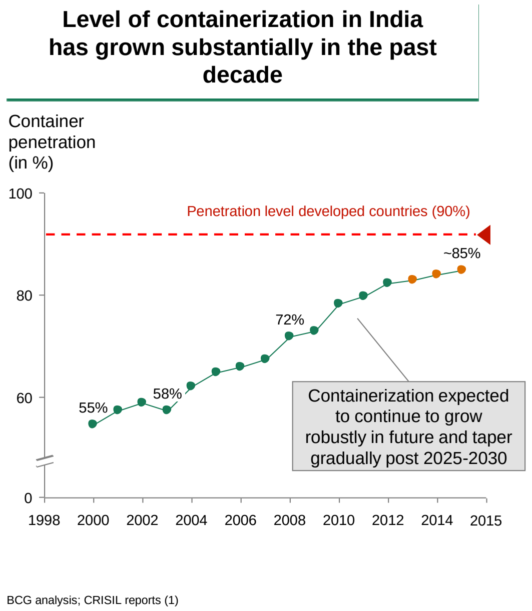


Figure 42: Underlying drivers for container traffic growth

1. <u>Containerisation:</u> The following figure illustrates that containerisation in India has still not reached global standards. This presents an opportunity for further containerisation of Indian cargo.



Infrastructure developments expected to drive containerization growth further

- **Container traffic is expected to register highest future growth among all types of cargo**
- **Major investments in ports to drive mechanization & improve productivity**
- **Privatization of ports expected to drive mechanization and containerization**
- **Recent investments in development of inland road/rail & waterways logistics**

Figure 43: Containerisation trend

2. Manufacturing Outsourcing: The following figures illustrate India's cost competiveness as a manufacturing outsourcing hub in comparison with major manufacturing hubs in the world and Asia. It indicates that India has significant potential for future growth, if the logistics and procedural challenges can be overcome.

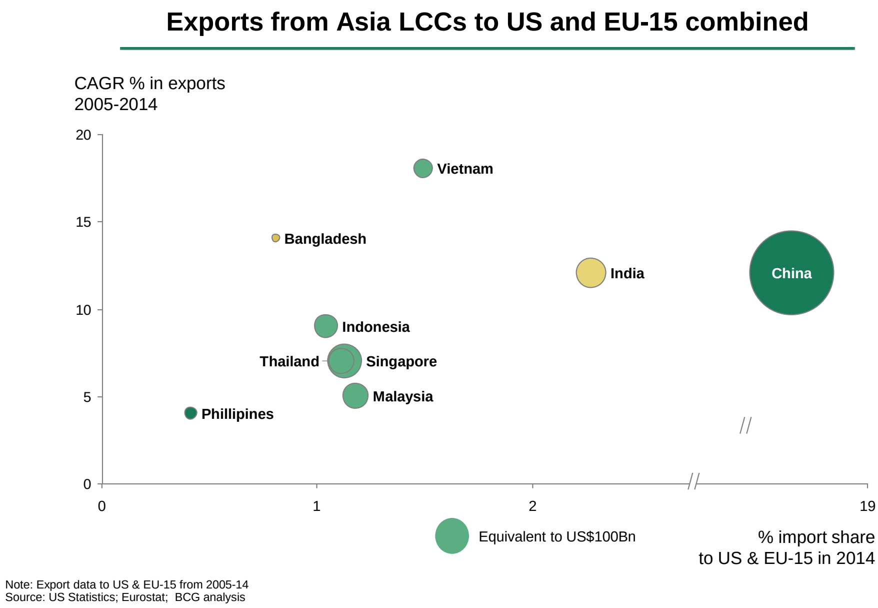
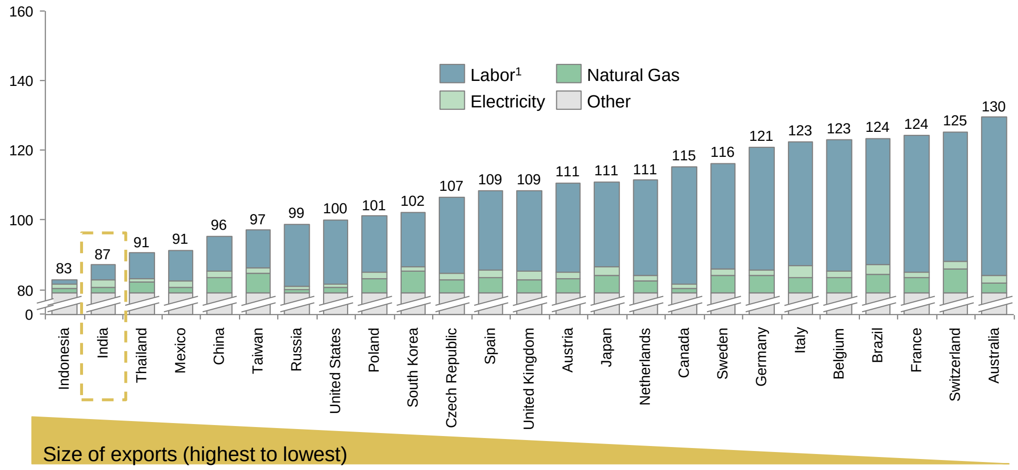


Figure 44: India's export growth vs. share of Indian goods in US, EU imports

Comparing the top 25 Export Economies for 21 key industries



Sources: U.S. Economic Census; Bureau of Labor Statistics; U.S. Bureau of Economic Analysis; International Labor Organization; Euromonitor International; Economist Intelligence Unit; BCG analysis
Note: The index covers four direct costs only. No difference is assumed in other costs, such as raw-metal inputs and machine and tool deprecation. Cost structure is calculated as a weighted average across industries
1. Adjusted for productivity

Figure 45: Manufacturing cost benchmark for top export economies

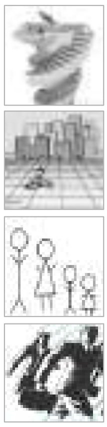
3. Consumption: The following figure illustrates the key drivers of consumption in India. The consumption growth in India is being driven by strong macroeconomic and demographic trends such as urbanization, nuclearization, age demographics etc. Thus, rapid consumption growth is expected over the next several which will also drive growth of container trade.

Consumption to grow 3.6X in 10 years...

($ billions)	2010		2020
Food	328	2.7x	895
Clothes and footwear	59	3.8x	225
Housing and consumer durable	186	4.0x	752
Health	49	3.8x	183
Transport and communication	168	3.9x	664
Education and leisure	71	4.2x	296
Others	129	4.4x	570
Total	991	**3.6x**	3,584

...driven by 4 key drivers

Income growth	**~3** times increase in average household income from 2010 to 2020
Urbani-sation	**35%** population will live in urban cities in 2020 (31% in 2010)
Nucleari-sation	**18Cr** nuclear households growing at 4% CAGR compared to 2% growth in total population
Growing work force	**137mn** more people will be added to the workforce by 2020 bringing the total to 752mn



Source: Euromonitor, NSSO; BCG Indian Consumer Survey December 2010, N=6278, BCG analysis

Figure 46: Consumption growth in India

In order to project the container growth in India, projections for GDP growth and scenarios of container multipliers have been developed.

The figure below shows projections of GDP growth in India. GDP growth is expected to pick up and continue to be strong at an average of ~6.5% for the next 10 years.

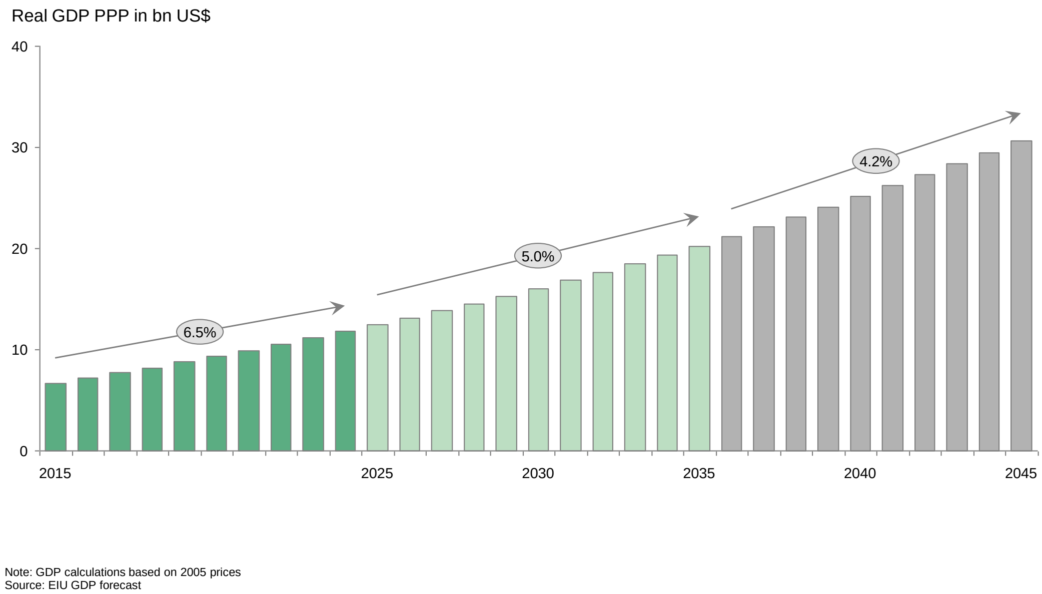


Figure 47: Indian GDP Projections for 30 years

As discussed earlier, the container growth is usually higher than GDP growth specially in developing economics. In India the container growth multiplier (container growth / GDP growth) has been between 1.7 – 2.3 over the last 20 years. In order to project container traffic growth using GDP forecast estimates, three scenarios (base, conservative and aggressive) for container multiplier has been developed using the projections of three underlying drivers that influence this multiplier – consumption, outsourcing and containerization. Similarly, three scenarios for GDP growth has been developed using the understanding of key underlying trends. e.g. . In aggressive case, the GDP can accelerate by a factor 1.1X over the base case projection of 6.5% growth, if "Make in India" initiatives are successful key infrastructure projects are implemented in time and are able to spur industrial growth.

The figure below describes the base, conservative and aggressive scenarios for container traffic projection developed using the scenarios of GDP growth and container multipliers.

	GDP growth scenario			x	Container growth multiplier			=	Container growth accelerator		
Scenario 1 (Aggressive)	1.1	1	1		1.7	1.4	1		1.8	1.4	1
	• Acceleration in GDP from timely implementation of infrastructure projects and acceleration due to 'Make in India' campaign				• Faster rate of containerization • Acceleration in container trade as a result of greater outsourcing share						
Scenario 2 (Base Case)	1	1	1		1.6	1.3	1.1		1.6	1.3	1.1
	• Base case growth assuming no major internal or external shifts in economic environment and historical pace of implementation of infrastructure investment projects				• Historical containerization growth, slightly lower outsourcing growth due to emergence of other low cost countries like Mexico, Indonesia etc.						
Scenario 3 (Conservative)	0.8	0.9	0.9		1.5	1.2	0.9		1.2	1.1	0.8
	• Lower GDP growth due to delays in infrastructure projects/ low response to 'Make in India' and a weak global economy (instability in Europe / slow revival of US)				• Slower growth of containerization due to logistic bottlenecks, erosion of manufacturing competitiveness and slow down in consumption						

2015-2025 | 2026-2035 | 2035-2045

Figure 48: Assumptions for scenario analysis

The scenarios have then modelled and developed into container volume forecasts. The traffic forecast over the next 30 years has been detailed out in the following figure. In 2030 India's container volumes are expected to reach 35-54 Mn TEUs in the base case

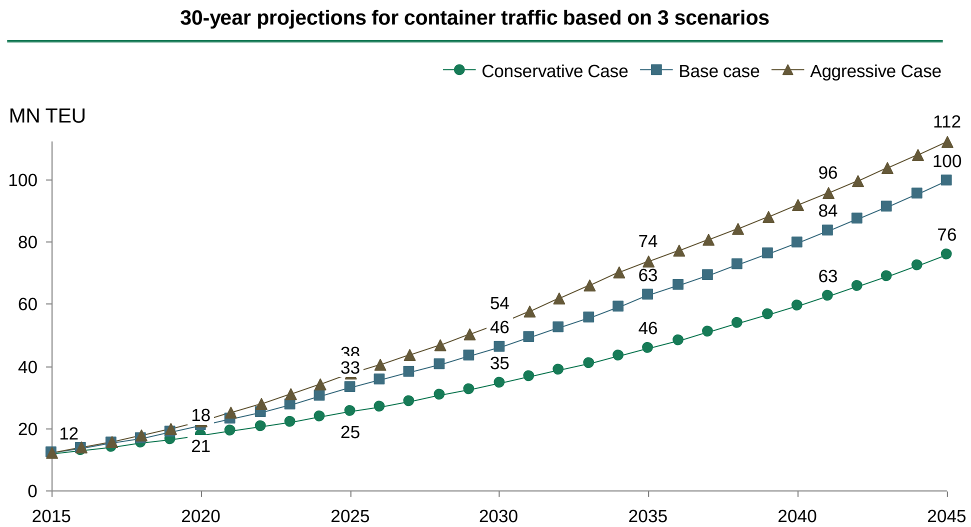


Figure 49: 30 year projection of Indian container cargo

6.2.1.2. Hinterland container traffic projections

The hinterland container volumes are projected through both top down and bottom up approach. For top down estimates, macro indicators like GDP and per capita income have been studied. For bottom up estimates, the hinterland has been studied in detail and both existing and potential sources of container traffic from the hinterland have been identified. The following figure lays down the approach followed for hinterland projections.

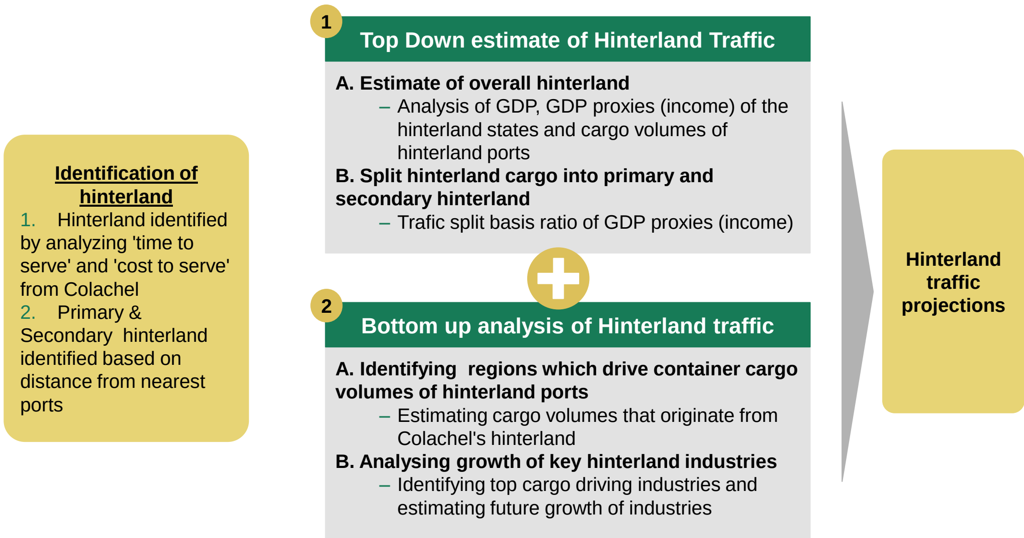


Figure 50: Approach for hinterland traffic projections

The first critical step in estimating hinterland traffic is to identify define the hinterland itself. The following figure presents the approach taken to define both the primary and secondary to deciding the hinterland and further has been detailed out in the following figure.

The hinterland identified for Enayam comprises of all districts of TamilNadu and Kerala, 26 districts of Karnataka and 12 districts of AP.

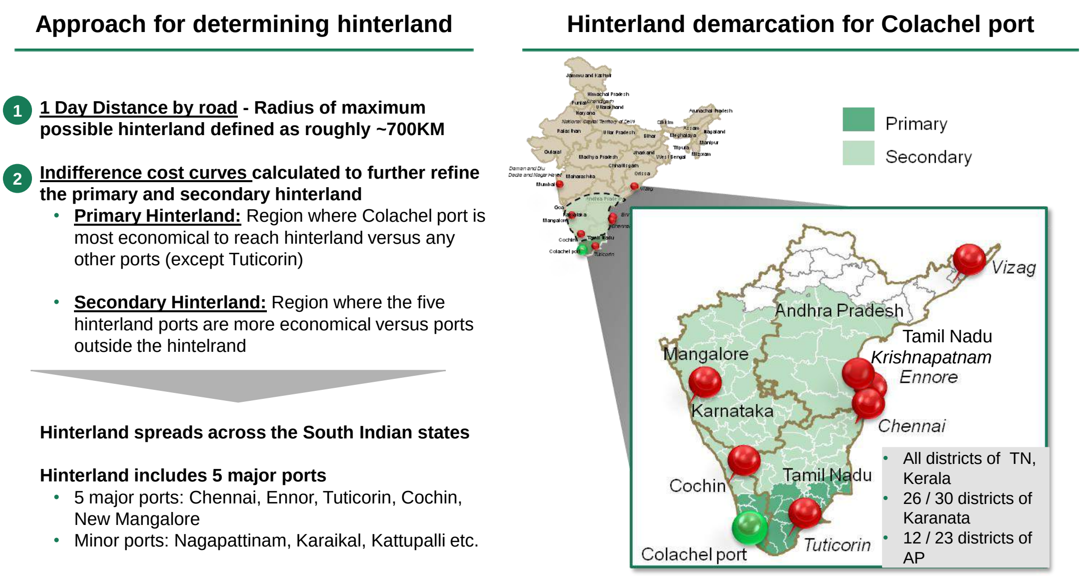


Figure 51: Hinterland identification for Enayam

For this hinterland, the top down and bottom up traffic estimates have been analysed as detailed below.

Top down estimate of hinterland traffic:

The approach taken for estimating of container traffic originating from the hinterland through top-down estimates is explained in figure below. Using this approach, the current hinterland traffic has been estimated as ~2.3 MN TEUs.

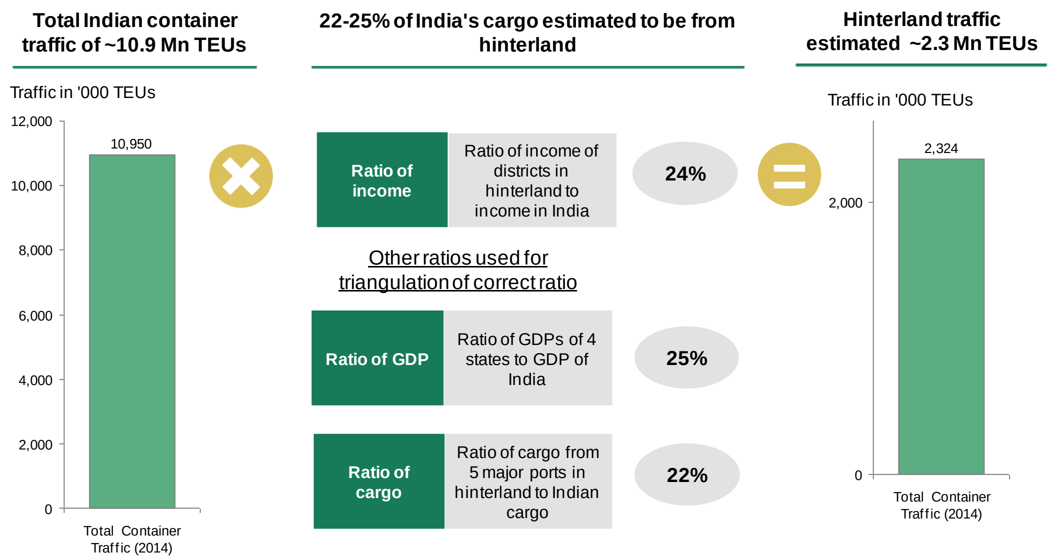


Figure 52: Hinterland traffic projection

Primary hinterland accounts for ~12% of hinterland traffic, rest originates from secondary hinterland, as described in the analysis shared in figure below.

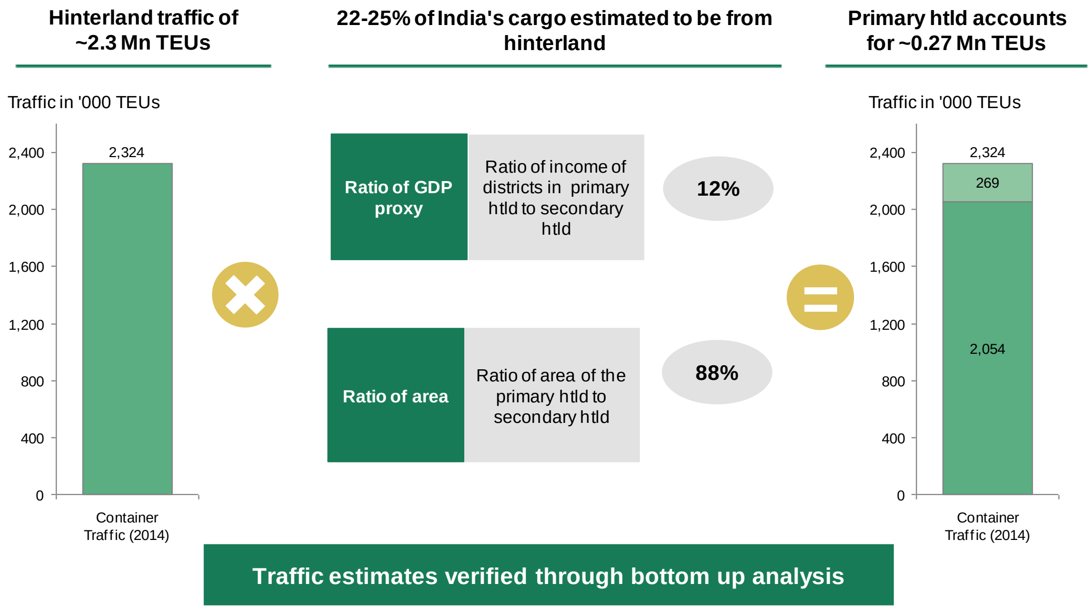


Figure 53: Split of hinterland traffic into primary and secondary hinterland

Bottom up estimate of hinterland traffic:

In bottom-up analysis, the hinterland regions that drive container traffic for the existing hinterland ports have been identified first. As seen from the figure below, 10 -15 districts account for 60-70% of traffic through each of the existing ports in the hinterland.

Key hinterland region for Chennai port

Port	Origin/ Destination	Import or Export	% of total cargo
Chennai	Chennai	Export	26%
Chennai	Krishnagiri	Export	21%
Chennai	Nellore	Export	14%
Chennai	Coimbatore	Export	4%
Chennai	Medak	Export	2%
Chennai	Khammam	Export	2%
Chennai	Kanchipuram	Export	1%
Chennai	Vellore	Export	1%
Chennai	Bangalore	Export	1%
Chennai	Chennai	Import	1%

Similar analysis done for Cochin; Mangalore and Ennore have negligible container traffic

Key hinterland regions for VOC port

Port	Origin/ Destination	Import or Export	% of total cargo
Tuticorin	Tirupur	Export	8%
Tuticorin	Coimbatore	Export	6%
Tuticorin	Chennai	Export	4%
Tuticorin	Tirunelveli	Export	3%
Tuticorin	Karur	Export	3%
Tuticorin	Bangalore	Export	2%
Tuticorin	Madurai	Export	2%
Tuticorin	Chennai	Import	4%
Tuticorin	Coimbatore	Import	4%
Tuticorin	Tirunelveli	Import	4%
Tuticorin	Kollam	Import	3%
Tuticorin	Madurai	Import	2%
Tuticorin	Bangalore	Import	2%
Tuticorin	Dindigul	Import	2%
Tuticorin	Sivakasi	Import	2%
Tuticorin	Virudhunagar	Import	2%

Key cargo driving regions fall within the hinterland areas of the ports

Figure 54: Sources of hinterland traffic

Further, the key industries in the hinterland such Agro Products, Textiles, Machinery, Auto, Food processing, Paper, Metals & Mining have been identified and mapped on the hinterland. Figure below shows the share of key industries in traffic and their origin in the hinterland.

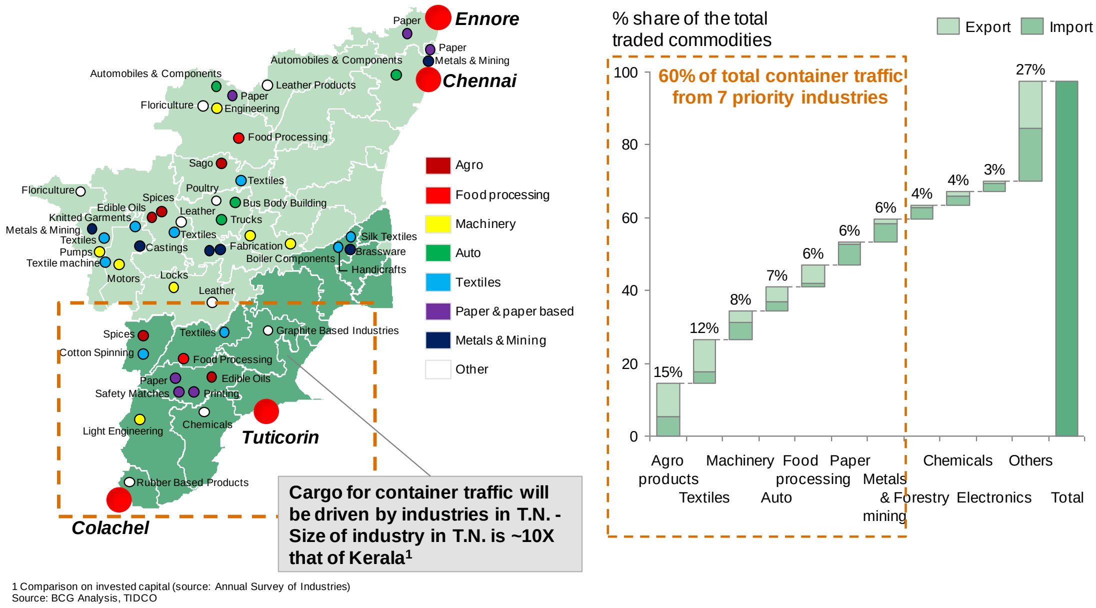


Figure 55: Map of hinterland industries and volumes from the industries

The export growth trends for the shortlisted industries have then been analyzed. India has seen consistent > 10% growth in most of the industries in the last decade.

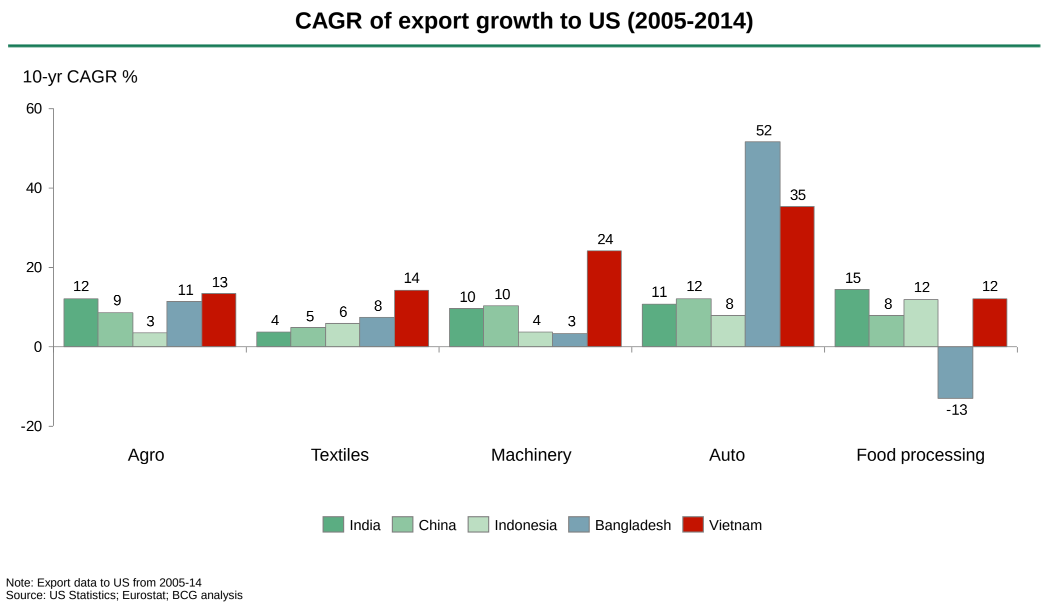


Figure 56: Export trends for the key hinterland industries

As a case example, textile industry is analyzed further. Two figures below reveal that India is well positioned in apparel manufacturing in terms of cost competitiveness, labour availability, productivity, compliance to international standards etc.

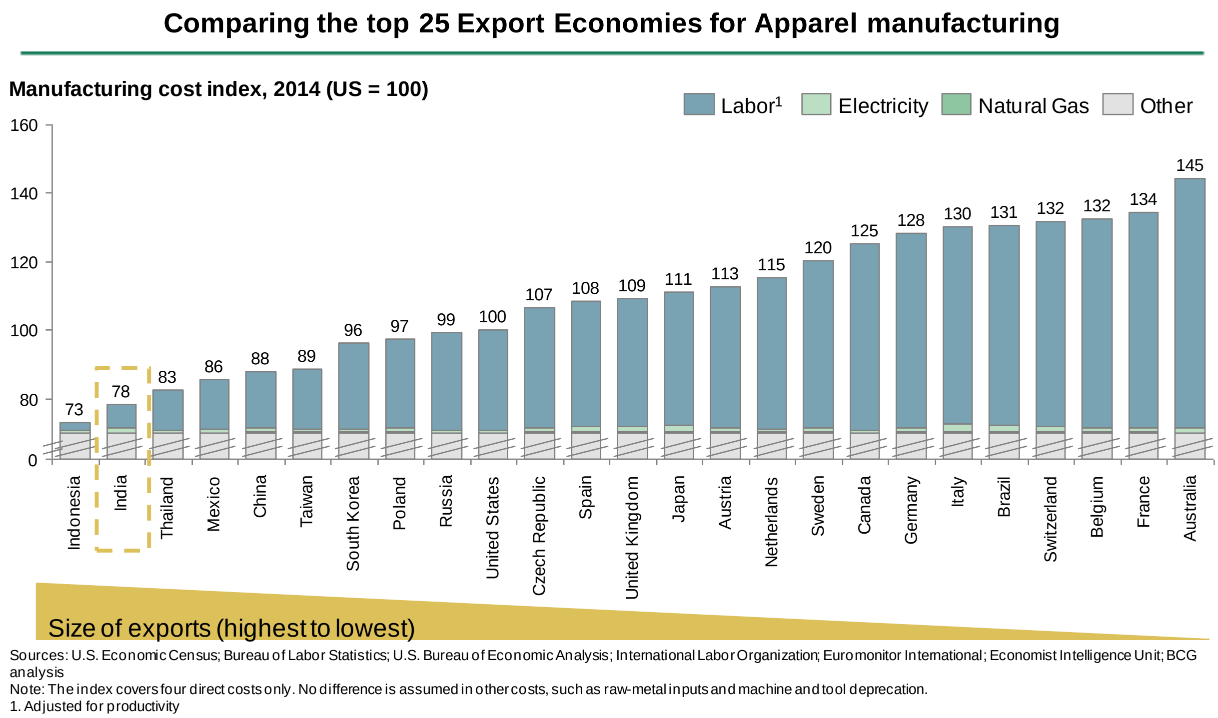


Figure 57: Comparison of cost competitiveness for top 25 export economies

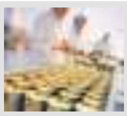
Country	Labour rate, productivity and Inflation			Labour pool	Raw material availability	Compliance levels	Country Stability
Figures in brackets are the 2012 knit exports in $ bn	*Monthly labour wage ($)*	*Labour productivity (%)*	*Wage Inflation (2008-2013) (%)*	*Economically active pop. aged 20 – 39 in '12 (in mn)*	*Availability of raw cotton, yarn and fabric for apparel production*	*Environment, safety and health compliance*	*Economic and political stability*
China (47)	330	70%	15%	343.9	Raw cotton, yarn and fabric available		
Vietnam (4)	170	55%	9%	20.2	Yarn and fabric imported		
Cambodia(1)	120	55%	28%	4.5	Yarn and fabric imported		
B'desh (9)	100	50%	24%	35.3	Yarn imported		
India (4)	140	50%	4%	232.1	Raw cotton, yarn and fabric available		

● - Very high ○ - Very low

Source: EIU country data, Expert interviews, Press search, BCG analysis.

Figure 58: Competitiveness of India in textile industries

Similar analysis has been done for all the key industries. Overall, the key industries in hinterland are expected to grow by 10-12 % as summarized in figure below. Overall, an estimate of 10 – 12% growth across the key industries over the next 10 – 15 years has been arrived at through this analysis.

Industry	Profile of the key hubs	Past growth trends	Key unlocks for further growth	Projected expected growth
 Textile	• **Key hubs : Tirupur, Madurai** • Tirupur accounts for ~40% of textile exports of India	• **15-18% CAGR** for last 10 years for Tirupur	• Possibility of renewal of FTA with European Union and Canada • Provision for interest subvention for the knitwear garment sector	• **15-20% growth** expected over next 5–10 years (as per Tirupur Exporters' Association)
 Paper based industries	• **Key hub: Sivakasi cluster,** Key consumer of imported paper • Imports for matchbox, printing and firecrackers industry	• **>10% CAGR for last decade** for Sivakasi matchbox industry	• FDI in retail to drive packaging industry • Growth of consumption (14% CAGR)	• Expected to continue **growth trajectory of 10–15%**
 Food products	• **Key hub: Across coastal area** • Key industries- Marine products (27% of TN's food exports) • Cashew products	• **18% CAGR** for Indian marine exports – similar trajectory for T.N. • ~9%% CAGR for TN cashew production	• Operationalization of agro parks in Nilakottai, Dindugul. by SIPCOT • Popularisation of new marine products like Vannamei shrimp	• Expected to continue **growth trajectory of ~10%**

All Key industries to grow at >10%; traffic growth estimate of 10–12% appears quite feasible even in primary hinterland

Sources: BCG Analysis, SIPCOT, TIDCO interviews

Figure 59: Description of key hinterland industries

Demand in Enayam will not only come from existing hinterland industriesand the development of the port will also spur new industries and accelerate development in earmarked SEZ and industrial zones. The following figure describes the potential of development of planned SEZ and Industrial parks. Basis, this analysis it is expected that a further 1 – 2% of additional growth is possible through the emergence of SEZ clusters and new industries. This upside has been captured in the aggressive growth scenario.

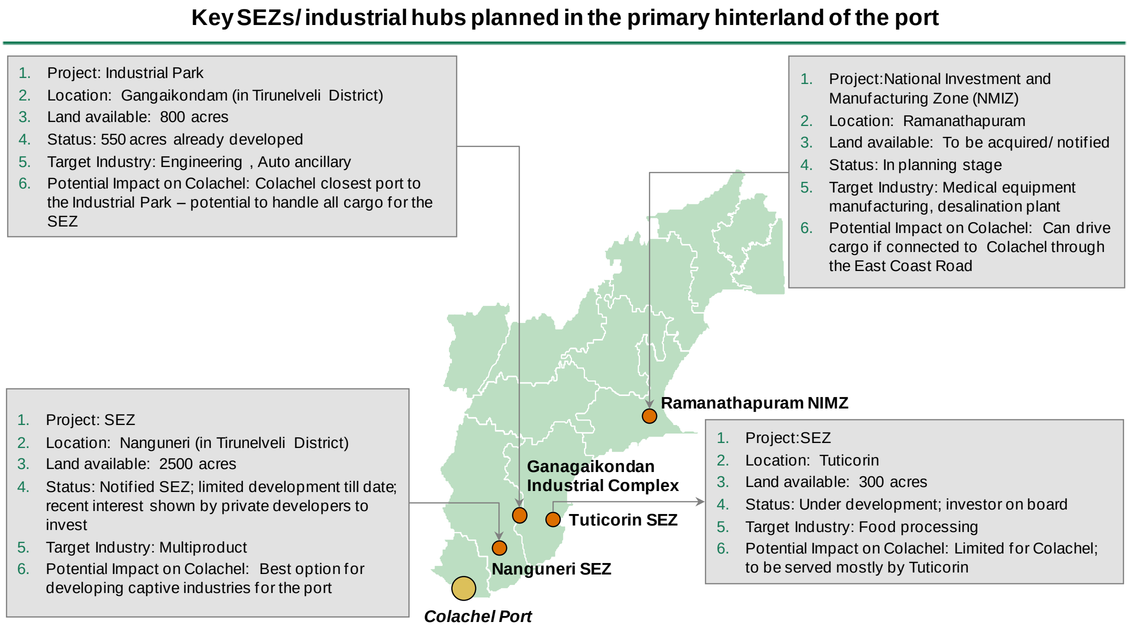


Figure 60: Potential SEZ, industrial parks in the hinterland in T.N.

Finally, both top down and bottom up hinterland traffic growth estimates have been compared and there is good convergence in both these estimates. Thus, these assumptions have been taken to project hinterland traffic growth. Hinterland traffic is projected to at 7.3 -11.5 Mn TEU in 2030 (figure below).

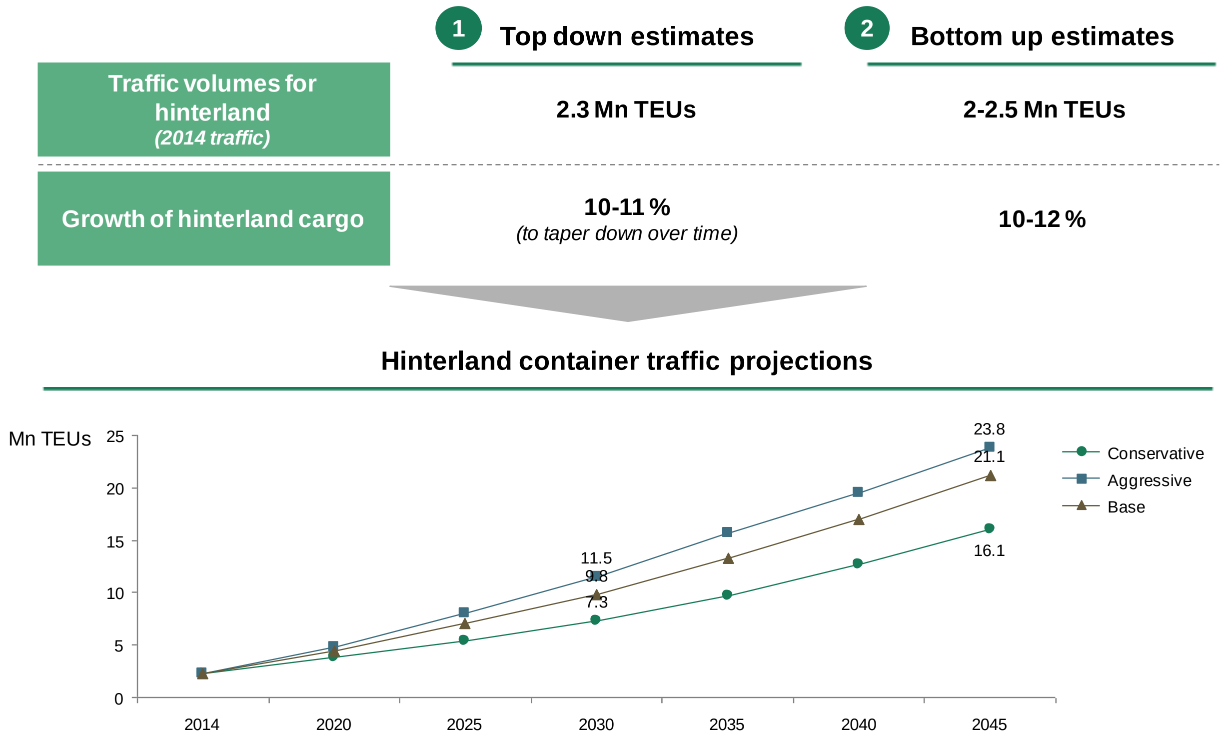


Figure 61: Hinterland traffic projections

6.2.1.3. Enayam container traffic projections

Container traffic for Enayam is projected by estimating traffic using the following approach

1. Trans-shipment cargo
    a. Continues to be trans-shipment cargo - Estimation of the likely share of Enayam from the existing trans-shipment traffic in the region.
    b. Gets converted to gateway cargo - Conversion of current trans-shipment traffic originating from hinterland into gateway traffic due to lower cost of logistics at Enayam (due to single port handling).

2. Gateway cargo

Enayam would also capture some of the existing gateway cargo that would get diverted from other hinterland ports due to proximity / lower cost of logistics.

The following figure describes the methodology for container traffic projection for Enayam.

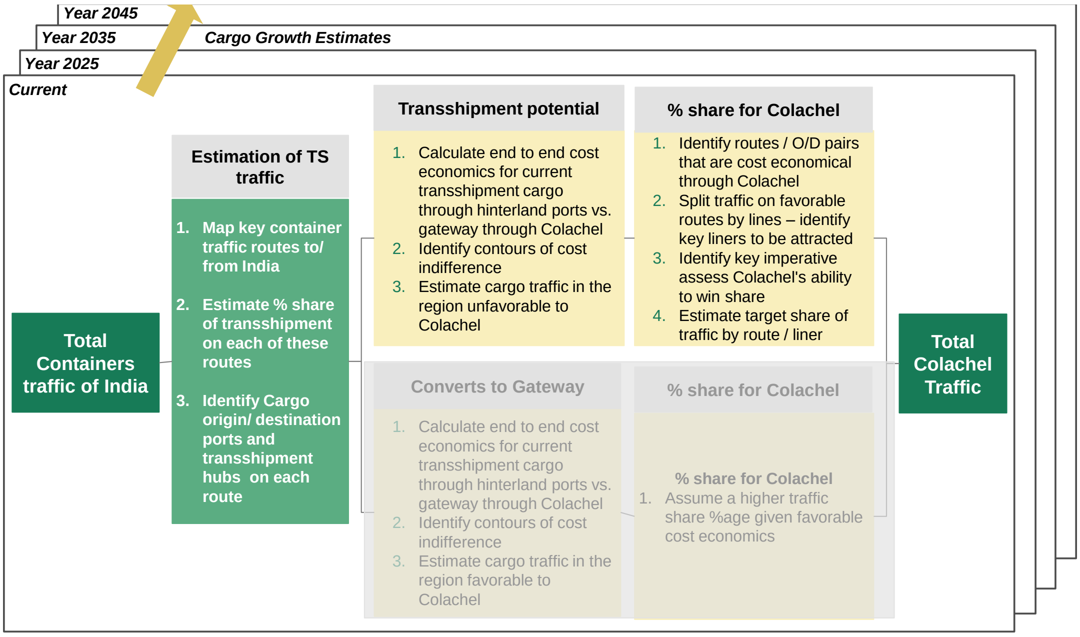


Figure 62: Description of methodology

1. Trans-shipment cargo
    a. Continues to be trans-shipment cargo

Enayam would need to not only match port charges of Colombo but offer ~15% discount in the first few years in order to become competitive and attract traffic from Colombo Port. This imperative has been assumed which estimating the traffic share for Enayam.

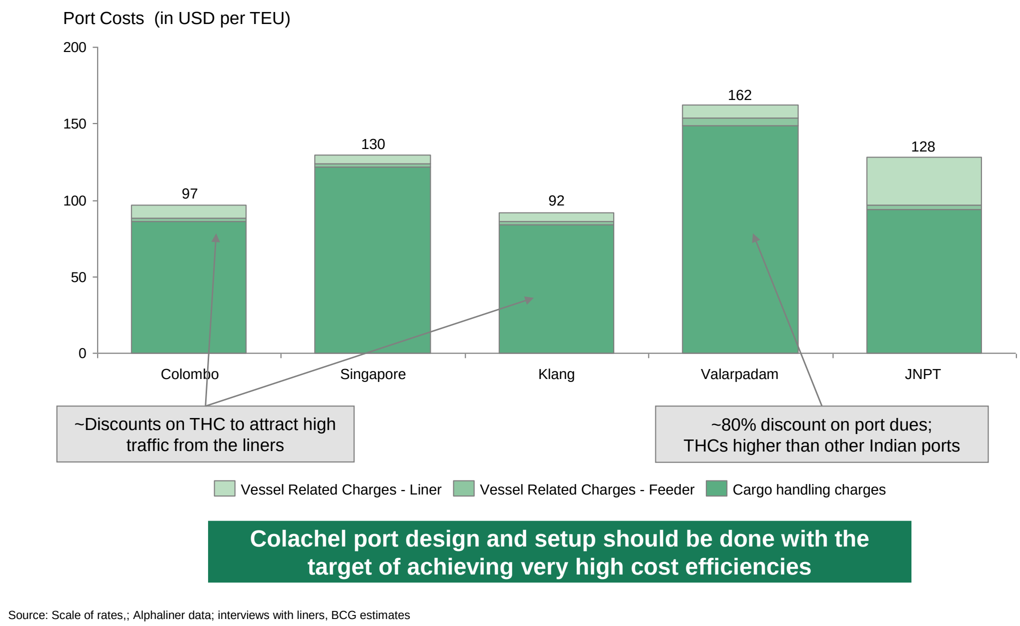


Figure 63: Comparison of port costs

Share of Enayam in trans-shipment cargo for different routes will depend on shipping cost competitiveness for Enayam versus other trans-shipment hubs. The next set of figures compare shipping cost on key routes for Enayam and other existing or potential trans-shipment hubs. This analysis assumes parity in port charges. In the "Without Cabotage" scenario feeder cost parity is also assumed.

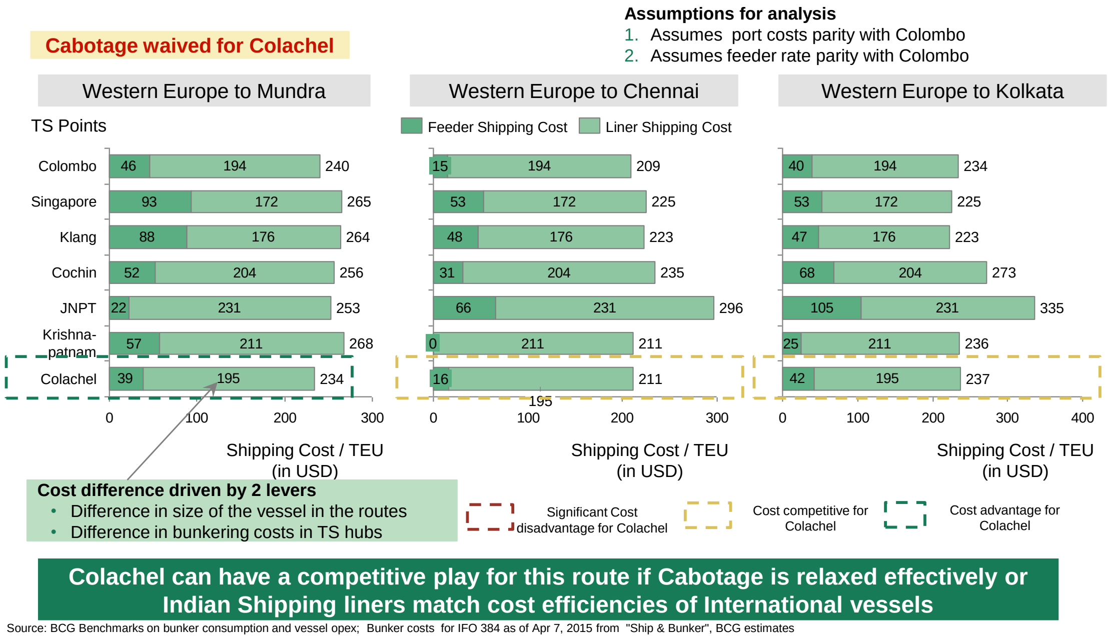


Figure 64: Comparison of shipping costs (1)

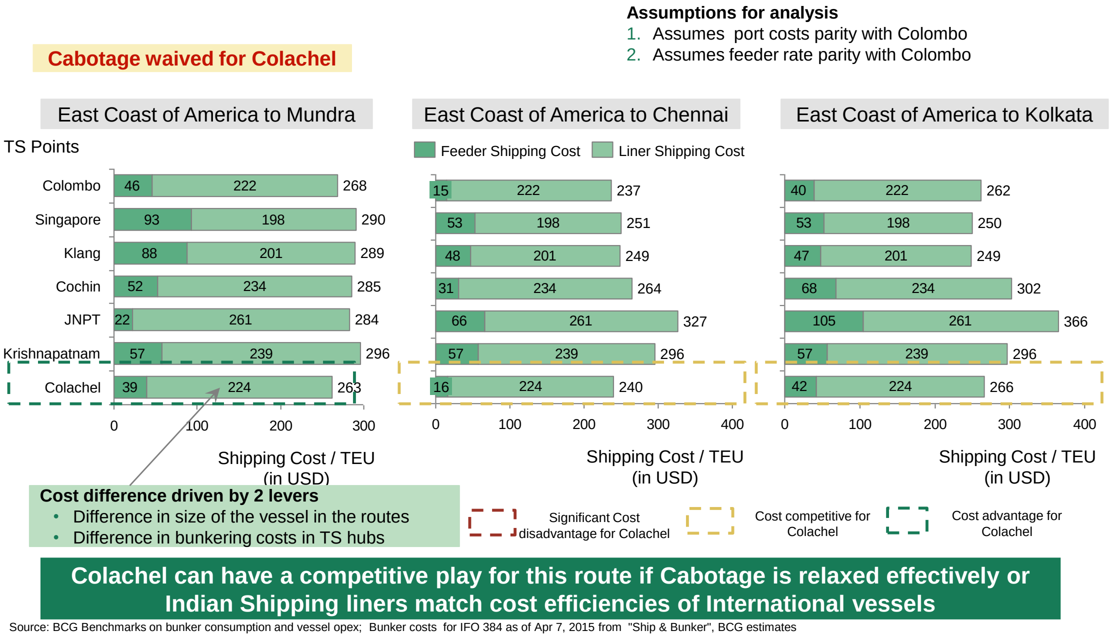


Figure 65: Comparison of shipping costs (2)

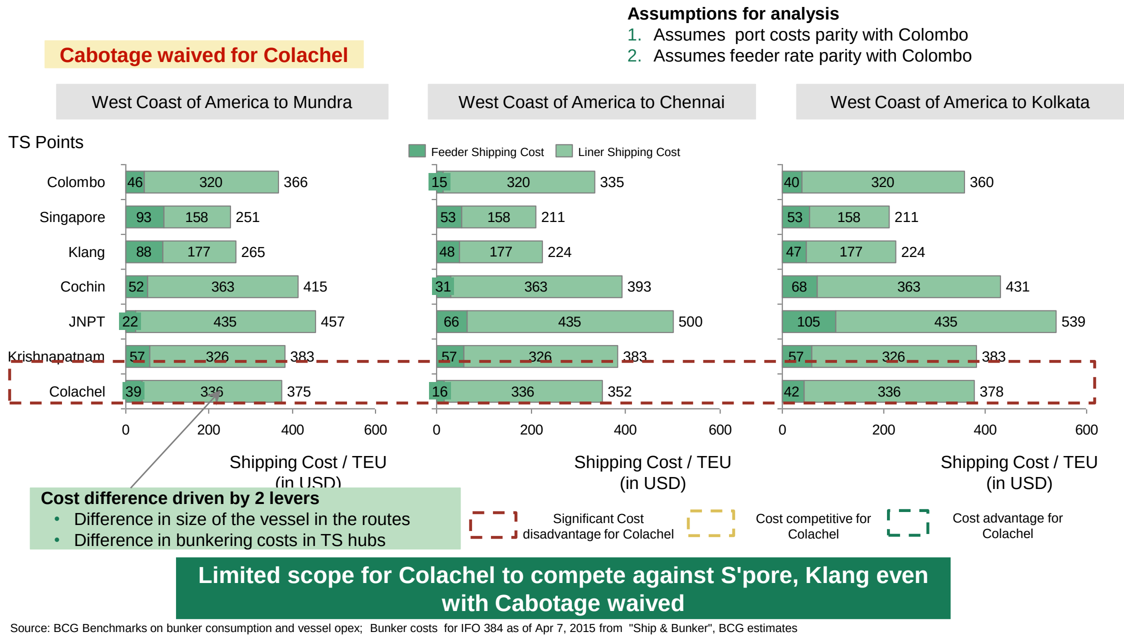


Figure 66: Comparison of shipping costs (3)

It is evident from the above analysis that Enayam, like Colombo will be at a competitive advantage versus Singapore and Klang for traffic moving to East Coast of US and Europe from West and South Coast of India (Chennai) and will be only at a marginal disadvantage for Cargo emerging from East Coast of India. On the other hand, Enayam will be at a significant disadvantage for the traffic moving to West Coast of America versus Singapore and Klang. These findings have been incorporate while building traffic share estimates for Enayam.

Further, the scale of operation impact has also been studied to determine the share potential. Currently, Singapore and Klang have significant scale which makes it attractive for liners to use as aggregation and relay hub for cargo across many routes. This is to bring down overall cost for liners, even if it increases cost on this specific route. This factor has also been incorporated while estimating target share for Enayam

Traffic Share Assumptions

- Traffic moving to East Coast of America and Europe
  - Share of current traffic through Colombo: ~50% can be moved to Enayam in base case
  - Share of current traffic through Singapore/ Klang: 25% can be moved to Enayam in base case
- Traffic moving to West Coast of America
  - Share of current traffic through Colombo: ~50% can be moved to Enayam in base case
  - Share of current traffic through Singapore/ Klang: <5% can be moved to Enayam in base case

The following figure shows different route wise projections for the Indian container traffic trans-shipped through the existing trans-shipment hubs

Indian Cargo transhipped through Colombo, Singapore, Klang
in '000 TEUs

	2018	2020	2025	2030	2035	2040	2045
Base Case							
Western Europe route	*1,046*	*1,285*	*1,573*	*2,221*	*3,050*	*4,086*	*5,180*
East coast of North & Central America	*1,340*	*1,641*	*1,846*	*2,554*	*3,473*	*4,653*	*5,899*
West coast of North & Central America	*1,240*	*1,524*	*2,334*	*3,421*	*4,666*	*6,251*	*7,924*
Conservative Case							
Western Europe route	*1,025*	*1,202*	*1,267*	*1,591*	*2,042*	*2,544*	*2,879*
East coast of North & Central America	*1,313*	*1,536*	*1,485*	*1,824*	*2,313*	*2,873*	*3,225*
West coast of North & Central America	*1,215*	*1,426*	*1,896*	*2,492*	*3,216*	*4,076*	*4,810*
Aggressive Case							
Western Europe route	*1,025*	*1,337*	*1,844*	*2,911*	*4,471*	*6,513*	*8,046*
East coast of North & Central America	*1,313*	*1,707*	*2,171*	*3,367*	*5,139*	*7,510*	*9,276*
West coast of North & Central America	*1,215*	*1,586*	*2,693*	*4,334*	*6,480*	*9,263*	*11,454*

1. *All estimates excluding TS cargo that is expected to be converted to gateway cargo in 2018*
2. *All containers double counted due to TS*

Note: Assumptions - % of trans-shipment remains same
Source:, IHS international trade data, BCG estimates

Figure 67: Traffic on different routes for Indian trans-shipment traffic

Traffic Projections

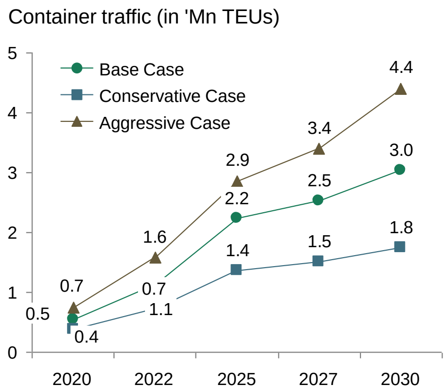
The following figure describes the projections for the trans-shipment traffic for Enayam. The traffic shares for Enayam are multiplied with the traffic estimates for each route to arrive at Enayam's traffic.

Key Assumptions for traffic projections

	Assumptions	2015-2025	2026-2035	2035-2045	Basis of assumptions
Colachel's share of TS traffic	*Colombo All routes*	10-50% rampup	~50%	50-65%	• Assuming 2 of the leading liners shift to Colachel • Low traffic in the initial years – shifting of routes to happen over a period of time
	S'pore, Klang Transatlantic routes	5-25%	~25%	25-40%	
	S'pore, Klang Transpacific routes	1-5%	~5%	5-20%	
Container traffic growth	*CAGR of container traffic (%)*	10-12%	6-8%	4-6%	• Higher GDP growth rate 6-7% in first 5 years, tapers down to 4%

2015-2025 | 2026-2035 | 2035-2045

Traffic projections for India based TS



1. Traffic estimated only includes TS traffic for India
2. Traffic excludes TS traffic from Chennai, VOC & Cochin that would get converted to Gateway traffic of Colachel (analysis in later pages)

Figure 68: trans-shipment traffic projections

Beyond India's traffic, Enayam would also gain share of Indian subcontinent traffic getting trans-shipped through Colombo. The following figure shows traffic projections for Indian subcontinent trans-shipment traffic that can be captured by Enayam.

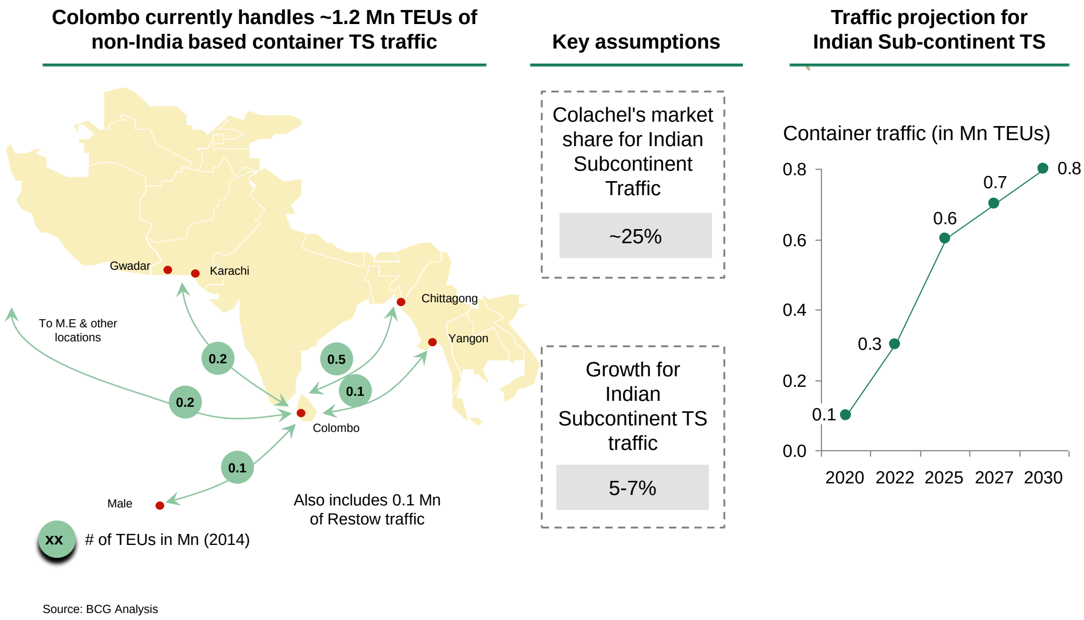


Figure 69: Indian sub-continent trans-shipment traffic for Enayam

The next step is to estimate the gateway traffic for Enayam. This is a combination of existing trans-shipment traffic at other Indian port, becoming gateway traffic for Enayam and gateway traffic captured from the hinterland. The estimations for gateway traffic at Enayam is discussed in the next sections.

Coastal traffic

Coastal container traffic for Colachel would be driven primarily by the feeder network carrying the trans-shipped EXIM cargo to other Indian ports. It will be ~1.5 Mn TEUs in 2030 (already included in the figure 84). Domestic coastal cargo expected to be handled in Colachel is negligible (at present, only ~0.6 Mn TEUs for domestic coastal cargo is handled across Indian ports).

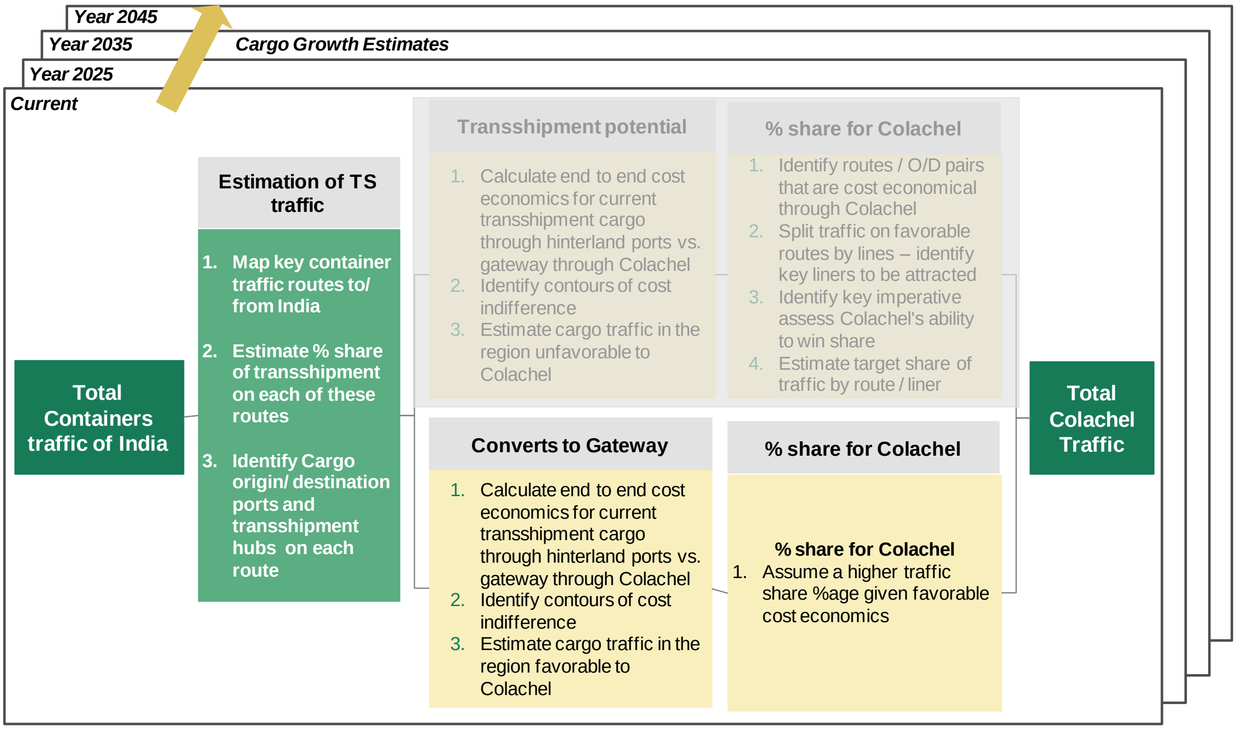
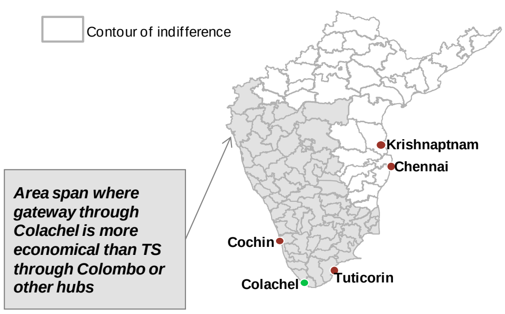


Figure 70: Description of methodology

2. Trans-shipment cargo
    b. Trans-shipment cargo getting converted to gateway cargo

Direct shipment of containers through Enayam instead of trans-shipment through Colombo will have a cost advantage for most exporters/ importers in the hinterland. The cost- benefit analysis is explained in figure below.

Potential to convert 40-50 % of TS traffic from South Indian ports to gateway



Port in hinterland	TS cargo (in '000 TEUs)	% of TS converted to direct cargo
CHENNAI	810	20-40%
V.O. CHIDAMBARANAR	433	>90%
COCHIN	204	>90%

Note: New Mangalore not considered for analysis as there is is no TS container cargo from New Mangalore

Economic simulation: ~ 30 % cost savings for cargo from Madurai district

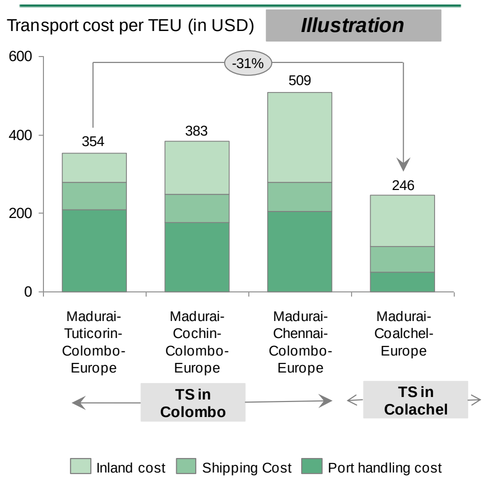


Figure 71: Trans-shipment traffic converted to gateway traffic through Enayam (I)

>50% traffic for each of the 3 major ports driven by 5-10 hinterland regions

Hinterland of Chennai port	• Key hinterland regions: Chennai, Krishnagiri, Nellore, Coimbatore, Medak, Kanchipuram, Vellore, Khammam, Bangalore • Accounts for ~70% of Chennai port's cargo
Hinterland of Tuticorin port	• Key hinterland regions: Bangalore, Chennai, Coimbatore, Madurai, Tirunelveli, Tirupur., Dindigul, Karur, Sivakasi, Kollam • Accounts for ~60% of VOCPT's cargo
Hinterland from Cochin port	• Key hinterland regions: Alleppey, Coimbatore, Kovalam, Kottayam • Accounts for ~60% of Cochin's cargo *(approximate estimate, to be confirmed through data from Cochin port)*

Cost for inland transport calculated for gateway to Colachel

Container rail services limited to selected regions
- CONCOR and private players have connected to selected regions – Chennai, Coimbatore, Madurai, Tirupur, Kanchipuram

Assumed Colachel will be connected to key roadways and rail network
- For road network: Connectivity to NH 7, NH 47, SH 179 and SH 91 considered
- For rail network: Connectivity to Eraniel

Basis logistics economics estimated hinterland cargo that will shift from TS to gateway
- **For Chennai port cargo** : ~35% of all TS traffic can be converted into Gateway through Colachel
- **For Cochin & VOC cargo:** ~90% of TS traffic can be converted into Gateway through Colachel

Figure 72: Trans-shipment traffic converted to gateway traffic through Enayam (II)

A detail district wise estimation has been done to identify the regions in the hinterland that will have a cost advantage to ship from Enayam. Basis this analysis, it is expected that~90% of exporters/ importers currently using Tuticorin or Cochin port for trans-shipment through Colombo are expected to shift to Enayam and ~35% of transporters using Chennai port are likely to shift as well. This has been then used to estimate the traffic for Enayam as explained in figure below.

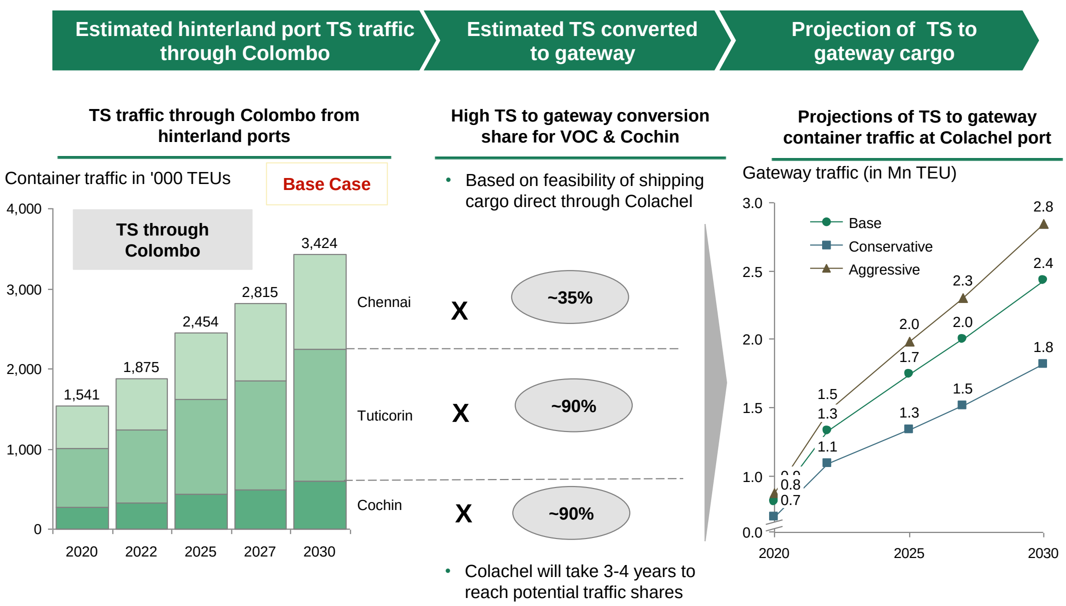


Figure 73: Trans-shipment to gateway traffic projections

3. Gateway cargo

Enayam is also expected to capture the existing gateway cargo from hinterland, for which Enayam will now be the closest/ most cost efficient shipping point (figure below)

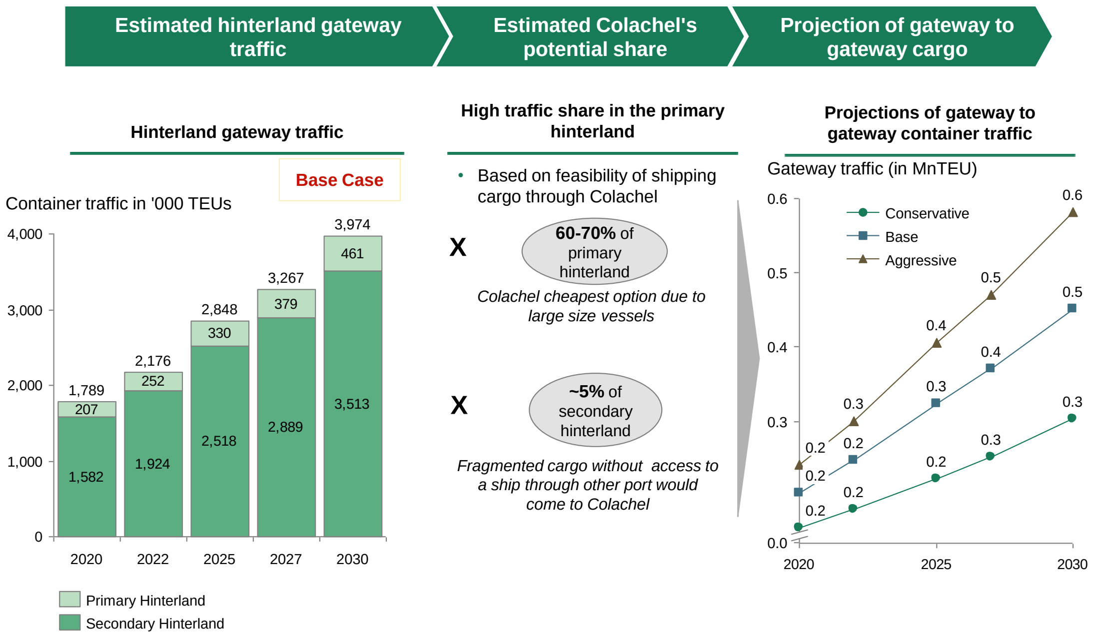


Figure 74: Gateway to gateway traffic projections for Enayam

Overall traffic estimates for container cargo after combining the trans-shipment traffic projection and gateway traffic projection is estimated to reach 5.9 Mn TEUs by 2030. The figure below summarises the container traffic projections for Enayam.

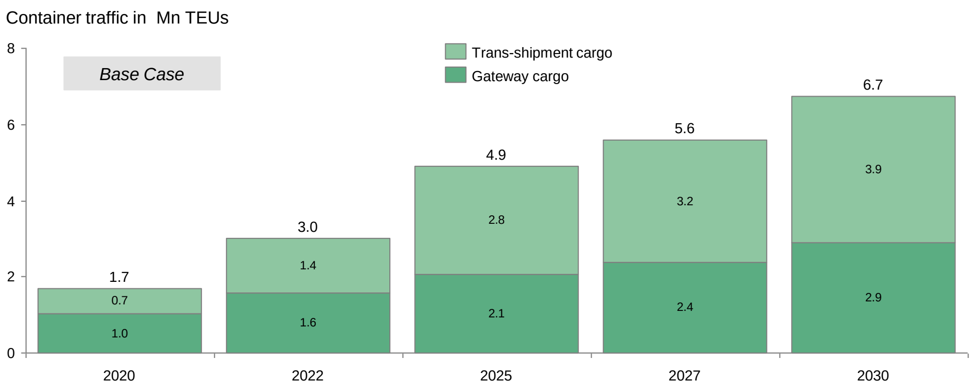


Figure 75: Container traffic projections for Enayam

6.2.2. Bulk traffic projections

Based on the detailed assessment of the bulk traffic, it clearly appears that share of coal is by far the highest amongst all bulk cargo in the hinterland. The coal traffic itself is driven by demand from thermal power plants. To project coal traffic in Enayam, two types of sources have been studied. The demand for new captive power plants and the demand for already planned power plants in the region. Further, projection has been made for new captive plants, beyond the planned period, by projecting the power demand supply gap in T.N. Finally, feasibility of Enayam to serve the planned power projects has been studied in detail.

The approach for bulk traffic estimation is described in the following figure.

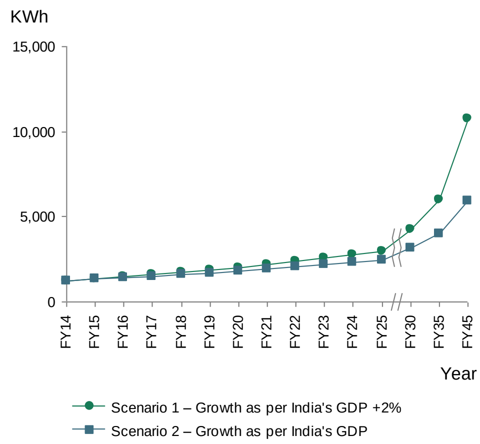
Key driver of bulk traffic	Power consumption estimation	Demand-Supply Gap	Traffic Projection
• Coal traffic drives majority of the traffic in the region • Estimate the portion of coal traffic in total and the drivers for coal traffic	• Project the power demand using historical trends and global benchmarks • Assess the pattern followed by other countries, particularly China	• Estimate the demand-supply gap in the coming years based on the planned supply of power plants in the next 5 years	• Forecast Colachel traffic by assessing the share of traffic it can take from planned power plants and captive power plant at Colachel

Figure 76 Approach for bulk traffic projections

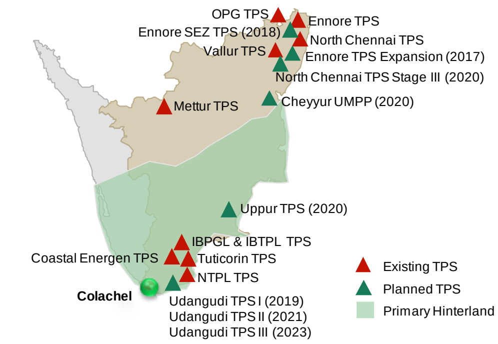
1. Captive Power Plants

Even after accounting for the proposed power plants in Tamil Nadu, it is estimated that demand will surpass supply post FY 22 (figure 64). Hence, there is a potential to develop a new power plant in Enayam to meet the gap in the subsequent years. (figure below).

Per capita power consumption forecast in TN



Existing and planned coal-based power plants in TN

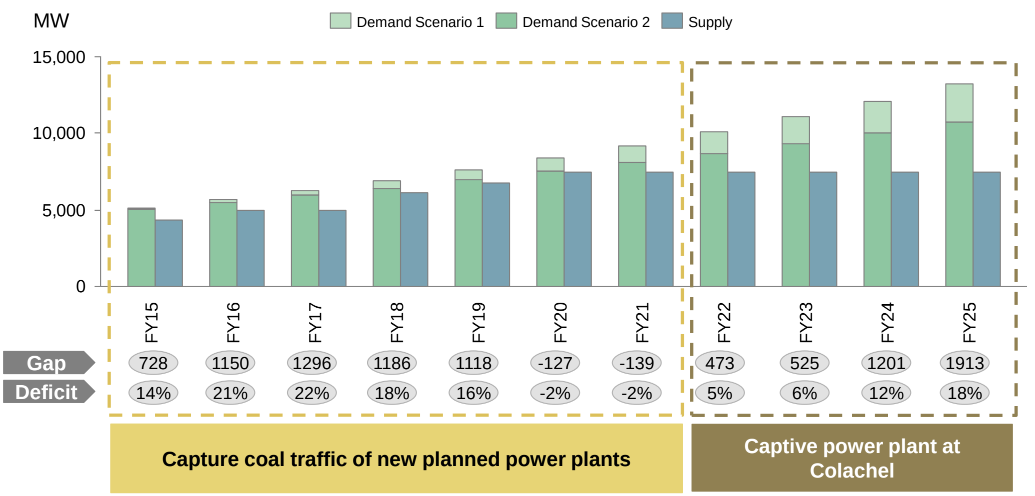


Year	FY17	FY18	FY19	FY20	FY21	FY22	FY23
Additional Supply in TN (MW)	660	1,320	1,320	4,000	1,320	-	1,320

Source: BCG analysis, Tamil Nadu Electricity Board

Figure 77 Power consumption estimates and power plants in TN

Power Demand – Supply Gap in TN



Source: BCG analysis

Figure 78 Projection of power demand supply gap in T.N.

Given the demand-supply gap projections, , it has been proposed that a unit of 660 MW each will be constructed starting from 2019, 2024 and 2028, each taking 3 years to construct (as per discussions with experts and TNEB officials) and operationalize in 2022, 2027 and 2031. Assuming an approximate requirement of 5000 tonne of coal per MW, each unit will require ~3 million tonne of coal in 2022, 2027 and 2031 onwards, totalling to ~9 million tonnes of coal requirement.

The exact details of land availability and ownership structure of this captive power plant can only be assessed in future. Keeping this in mind, a polyvalent berth has been planned, so that the same berth has the flexibility to be used for container traffic in case coal traffic does not materialise from captive power plant. Also, the berth has been designed for a capacity of 6 million tonne considering only the traffic expected till 2030 and can be expanded later depending on actual traffic till that point.

2. Existing planned power plants

Among the currently planned power plants, Enayam can potentially serve the Udangudi power plants. This is subject to Udangudi not getting serviced by the Tuticorin port due to capacity constraints and the captive jetty project in Udangudi not getting implemented. Hence, this is accounted in only the aggressive traffic scenario for Enayam.

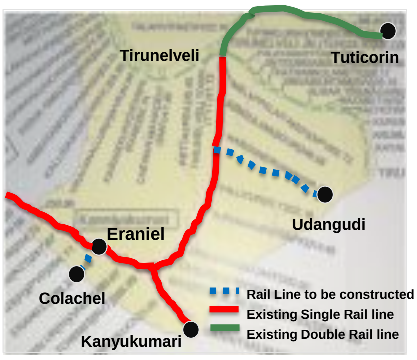
Traffic and capacity plan for Tuticorin

Coal Traffic (MTPA)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23
VOC Capacity	24	24	24	24	24	24	24	24	24	24
VOC Outer harbor capacity [1]							20	20	20	20
Total demand	6.8	13.8	13.8	13.8	13.8	20.4	28.4	35	35	41.6
Existing Traffic	6.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
Uppur TPS							8	8	8	8
Udangudi TPS I						6.6	6.6	6.6	6.6	6.6
Udangudi TPS II								6.6	6.6	6.6
Udangudi TPS III										6.6

More economical for Udangudi to source coal from VOC or through captive coal jetty; however both projects require high initial investments

1. Outer harbor expected to add 20 MTPA capacity in 2019-30 and further 10 MTPA capacity post FY 30
Source: BCG analysis, IPA team Report on VoPT Outer Harbour Development

Udangudi TPS potential opportunity for Colachel



Power plant development plan (total coal demand 18 -20MT):
- Phase 1: 2 x 660 MW by 2019
- Phase 2: 2 x 660 MW by 2021
- Phase 3: 2 x 660 MW by 2023

Potential options for servicing the power plant
- Option 1: Captive Jetty with a capex of Rs. 2000 Cr
- Option 2: From Tutiorin through rail; distance of ¬ 100 kms
- Option 3: From Colachel through rail; distance of ¬120 kms

Figure 79 Evaluation of options for Enayam to cater to Udangudi

The following figure describes the three scenarios for coal traffic projection and gives projection of Coal traffic for the port in each scenario.

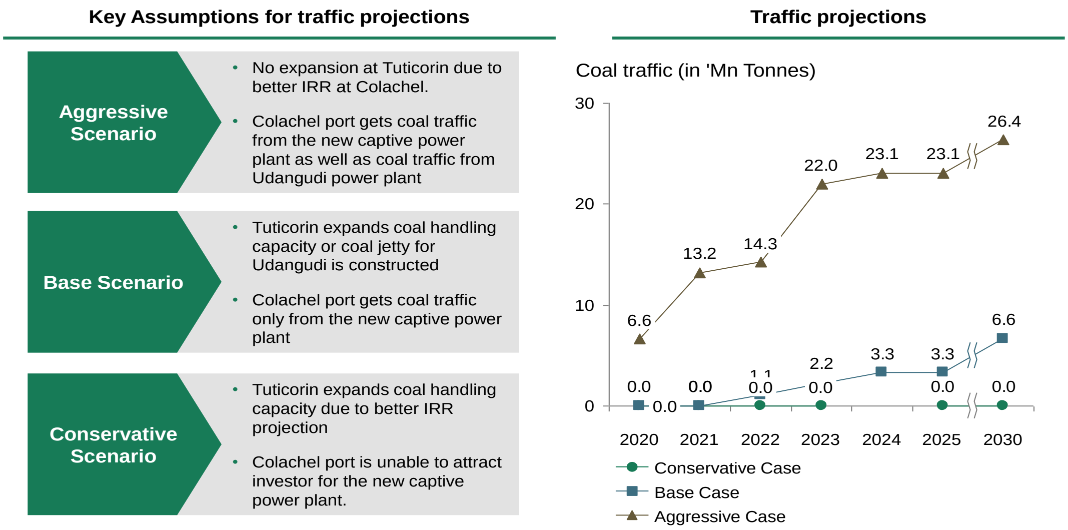


Figure 80 Coal traffic projections

6.2.3. Liquid traffic projections

Oil refineries are commonly located at regions with close access to ports. However, as seen in the following figure, the existing refineries and the planned ones are not in proximity to Enayam port location. As per the petroleum ministry and oil companies, there is limited possibility of deviating from the planned refinery rollout. Hence, the study does not account for any POL traffic for the port. However, possibility of POL traffic can be re-evaluated at a later date.

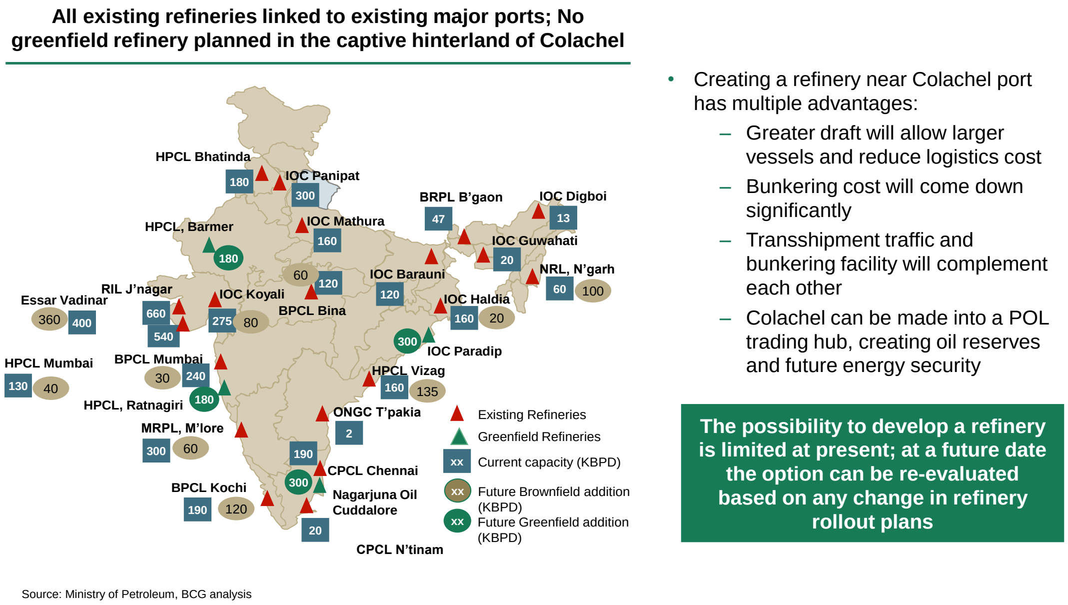


Figure 81: Feasibility of refinery in proximity to Enayam port

6.3. SUMMARY OF TRAFFIC ESTIMATES

The following figure summarises the traffic estimates for the Enayam port. As per the base case, the port will see container traffic of 6.8 Mn TEU (2.9 Mn of Gateway traffic and 3.9 Mn of trans-shipment traffic) and coal traffic of 6.6 MMTPA in 2030. The port layout and phasing of capacity for the port is planned as per the traffic estimates.

Container Cargo						
Base Case						
	units	**2020**	**2025**	**2030**	**2035**	**2040**
Gateway	*in Mn TEU*	1.0	2.1	2.9	3.9	5.0
Trans-shipment	*in Mn TEU*	0.7	2.8	3.9	5.2	8.0
Total		**1.7**	**4.9**	**6.7**	**9.1**	**12.9**
Aggressive Case						
	units	**2020**	**2025**	**2030**	**2035**	**2040**
Gateway	*in Mn TEU*	1.1	2.4	3.4	4.7	5.8
Trans-shipment	*in Mn TEU*	0.9	3.5	5.2	8.8	13.1
Total		**2.0**	**5.9**	**8.6**	**13.5**	**18.9**
Conservative case						
	units	**2020**	**2025**	**2030**	**2035**	**2040**
Gateway	*in Mn TEU*	0.9	1.6	2.1	2.8	3.7
Trans-shipment	*in Mn TEU*	0.5	2.0	2.6	3.3	4.2
Total		**1.4**	**3.5**	**4.7**	**6.1**	**7.8**
Bulk Cargo (Coal)						
	units	**2020**	**2025**	**2030**	**2035**	**2040**
Base Case	*in Mn MT*	-	3.3	6.6	9.9	9.9
Aggressive Case	*in Mn MT*	6.6	23.1	26.4	29.7	29.7
Conservative Case	*in Mn MT*	-	-	-	-	-

Figure 82: Traffic Projections

6.4. FEASIBILITY OF ANCILLARY INDUSTRIES

Creation of a major hub port also creates the opportunity to develop allied industries around the port. This would lead in creation of more jobs and will provide a major boost to the local economy. The possible industries include ancillary industries to support shipping activities, shipping related services and other industries that can develop in proximity to the port area. The following figure lists down the possible allied industries.

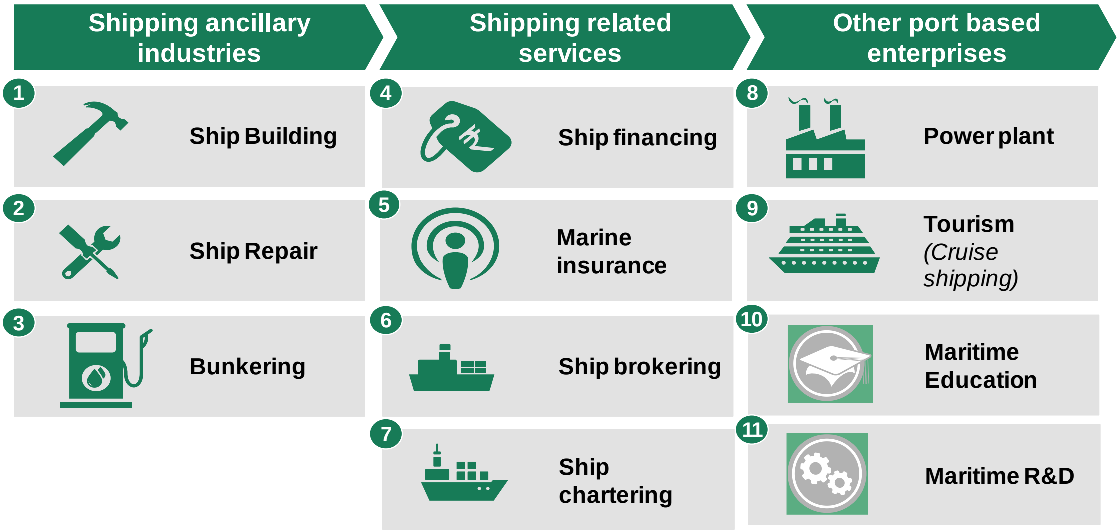


Figure 83: Allied Industries

This section analyses feasibility of each of the industries in context of the Enayam port.

1. Shipbuilding

Globally, the shipbuilding industry is struggling with overcapacity leading to closures and bankruptcies of ship building companies.

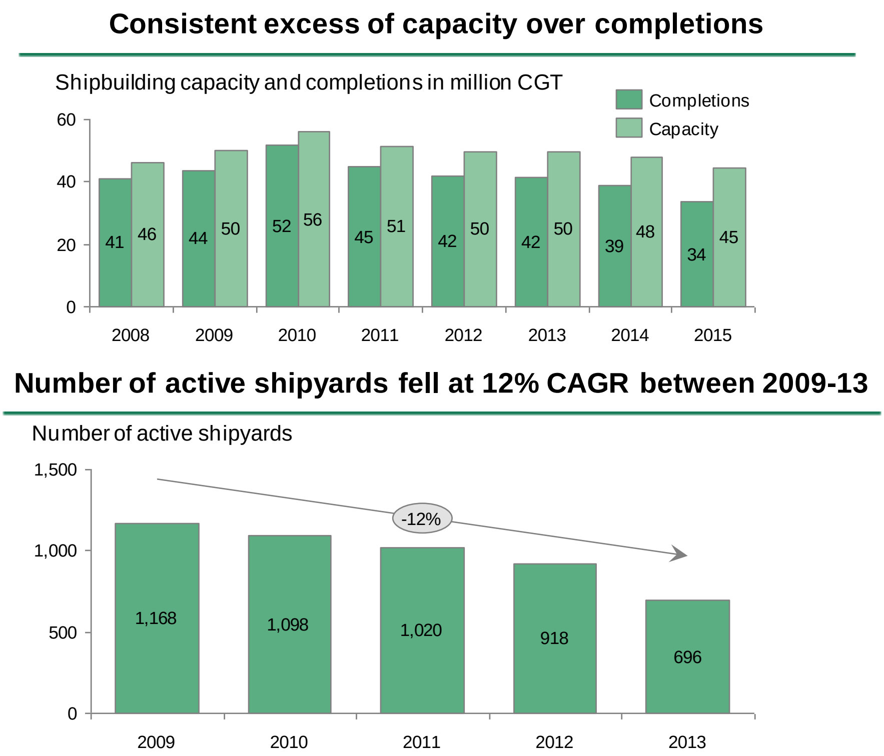


Figure 84: Global overcapacity in shipbuilding

Many shipyards have been closing amid the demand glut.

- STX Finland closed the world's leading ferry builder
- 1/3rd of China's yards may close by 2018 – according to trade association for China's shipbuilding industry
- Chinese shipbuilder Ronsheng laid off 80% of workforce in 2 years
- Number of active shipyards fell from 1168 in 2009 to 696

The situation is expected to continue as majority of current fleet would not get replaced in the next 5-10 years. Hence, the effects of surplus tonnage are long-term.

Amongst the four main shipbuilding sub sectors, only defence looks feasible for Enayam.

4 Main Shibuilding Sectors		Key Challenges and Opportunities
Commer-cial	• Liquid, dry bulk, container vessels • Dominated by China and Korea	• Difficult to compete with China's heavy govt. subsidy and Korea's technical sophistication • Low labour productivity in India – 55 man days/ton versus Japan's 25 man hours /ton offsets cheap labour • High material cost because of dependency from steel imports
Defence	• Warships, aircraft carriers, submarines for the Indian Navy	• Indigenous shipbuilding - 60% of Navy's acquisition budget • Low productivity – 1.33 and 0.48 ships per year for MDL & CSL respectively against international standard of 5.7 and build time 4 times international standard • Indian navy's demand > capacity of public shipyards • Make in India push to spur demand for Indian-made defence vessels • Opportunity for new players with estimated 95 vessels due for acquisition by Navy by 2027
Inland and coastal vessels	• Transport of goods through navigable waterways and along coast	• Yard must be located close to a river bank • Lack of automation – inability to deliver large orders • Inland water transport only 1% of transport market • Coastal shipping – 7% domestic cargo
Service	• Dredging vessels, offshore supply/supportessels	• Dutch monopoly on dredging vessels • Offshore vessels dominated by Singapore, Norway, China • Oversupply of offshore vessels => low new-build order volume

Source: Discussion with expert; media reports, report by working group, industry reports

Only feasible option

Figure 85: Main shipbuilding sub sectors

2. Ship repair

Ship repair can be broadly classified into two types – scheduled and unscheduled.

Scheduled ship repairs

- Pre-planned, scheduled maintenance activities for vessels
- Schedule ship repair required -
  - to ensure seaworthiness
  - to keep ship in optimum operating condition to maximize earning capacity
  - to pass class inspections by classification societies
- Dry docking facility needed
- Indian vessels go to hubs in Dubai, Singapore, China currently

Unscheduled ship repairs

- Includes minor repairs, which are defined as those limited to the vessel's superstructure, deck and hull above the waterline
- Minor repairs do not need dry dock
- Examples: replacement of seals on hatch covers, minor engine repairs, repairs to lifting equipment or rigging etc

Figure 86: Types of ship repair

Scheduled repair facility is not critical to attract traffic and will be difficult to establish due to investment and land requirements

Key characteristics

- Ship operators try to minimize time spent on scheduled repairs– not more than 9 days in two years
- Periodic activity, so operators plan and choose port as required
- Ships aim to complete all scheduled maintenance activity at one location

Implications

- Not critical to attract traffic
- Full spectrum of services need to be offered in integrated facility

Requirements

- Land requirement > 1000 acres –
  - waterfront acreage for dry docking and berthing large ships
  - lifting installations
  - machine shop
  - training centre
  - electrical shop
  - carpenter shop
  - trade shop
- 20,000-25,000 tradesmen required with supporting social infrastructure

Comparison with Colombo

- Ship repair traffic only ~5% of vessel traffic -Most vessels port do not call because of availability of scheduled repair facilities
  - Colombo Dockyard serves ~200 vessels annually while over 3870 vessels handled overall

Figure 87: Scheduled ship repair

However, minor ship repair services can be offered by Enayam port. Minor ship repairs would also help the port to be competitive. Minor ship repairing services includes:

- Inspection and degasification of tanks
- Certification
- Cleaning

- De-rusting of pipes
- Spare parts
- Replacement of seals on hatch covers
- Minor engine repairs

The requirements to set up a facility for minor ship repairs are:

- Inventory of spare parts and components
- Ship repair berth
- Simplified custom bonding process to save on time and cost

3. Bunkering

Bunkering services can be an additional source of income as well as an added service to attract liner vessels. As discussed in POL traffic section, Bunkering is not possible in Enayam through a hinterland bunker supply. However, Enayam can still provide bunkering services through traded fuel.

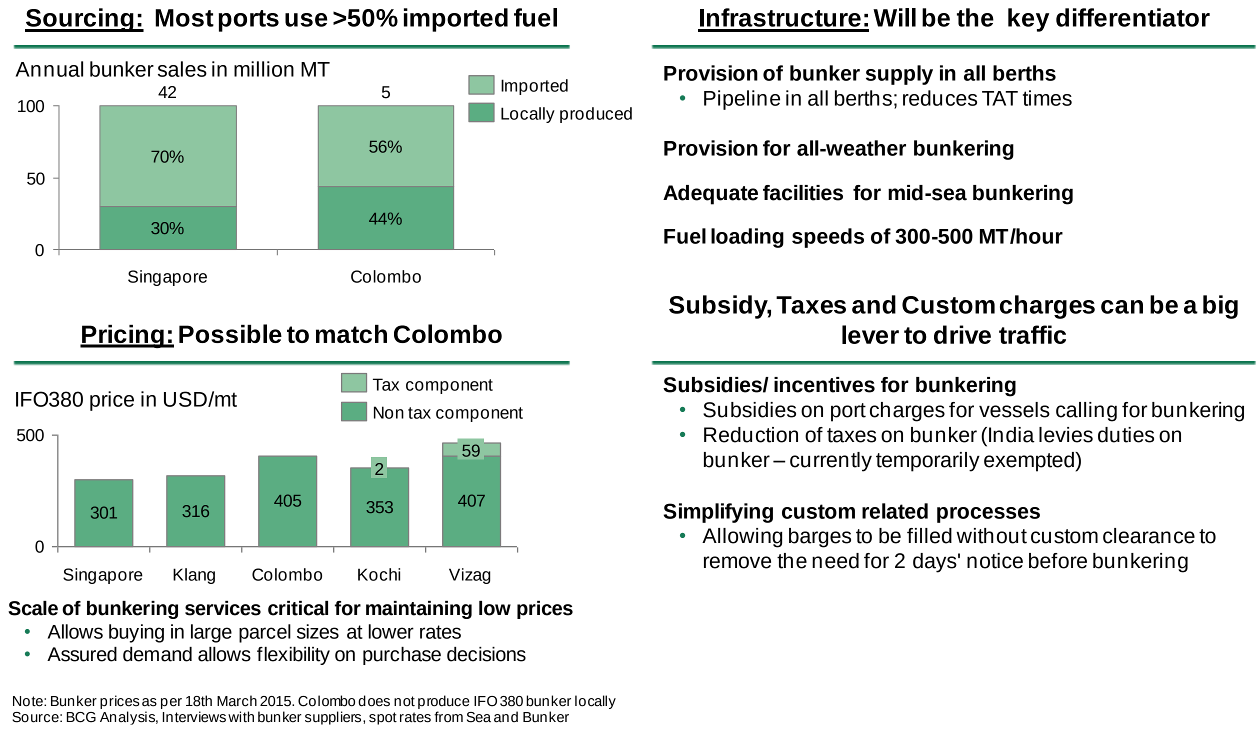


Figure 88: Possibility of bunkering facility in Enayam

To create a differentiation through bunkering services, it is critical to achieve high process related efficiencies (high fuel loading speeds etc.) and state of the art facilities (all weather bunkering etc.). The industry will also need support in terms of tax and duty breaks at least in the initial years.

4. - 7. Ship related services

Four key ship related services were shortlisted for study – ship financing, marine insurance, ship broking and ship chartering. All the services are dominated by global players in form of major banks, insurers, shipbrokers. Moreover, these services are usually run out of major financial hubs and large metropolitan cities. Hence, feasibility of developing these service industries near Colachel is limited.

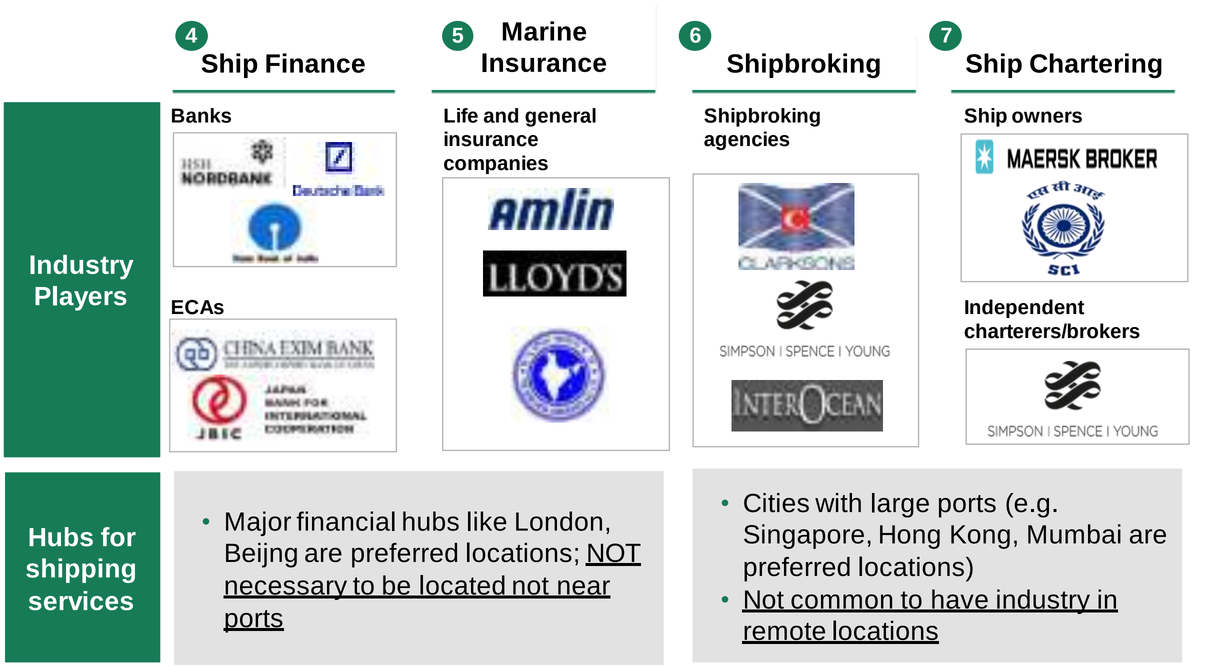


Figure 89: Ship related services – major players and locations

8. Power plant

Power plant would be feasible based on power supply demand gap in Tamil Nadu in FY 22. The section on bulk cargo discusses possibility of power plant in details.

9. Cruise shipping

All cruise shipping centres in India and globally are either home ports or ports-of-call. Enayam/ Colachel has been evaluated for both home port and port-of-call. Enayam lacks both cruise destinations and major cities in the vicinity of the port, making it difficult for Enayam to attract cruise shipping industry.

Homeport Attractiveness

Parameter	Colachel attractive?	Reason
Access to major markets	No	Distance from major cities: nearest metro >700 km Nearest airport 65 km away
Lodging	No	Mostly 2 and 3 star hotels – not attractive to cruise passengers
Crew travel cost	No	Cost high because of distance from major hubs
Overall attractiveness	**No**	

Port-of-call Attractiveness

Parameter	Colachel attractive?	Reason
Range of tourist attractions	No	Main tourist sports are Thomaiyar Kovil church and Padmanabhapuram palace
Adventure/activities	No	No major hotspots in and around Colachel
Depth of port	Yes	20 m deep draft available
Overall attractiveness	**No**	

Figure 90: Cruise port attractiveness

10. Maritime education and R&D centre

Indians form the second largest pool of sea farers in the world accounting for 10-15% of global pool of shipping crew (~15% for global officer pool and ~10% of global rating pool). Marine education infrastructure is critical for sustaining and expanding the Indian sea farer base. India today has more than 120 marine education institutes which are recognized by DG Shipping (~70 % of the institutes are part of engineering colleges). Although the no. of seats in India for marine education is adequate, the quality of education has always been under scrutiny. The DG Shipping had imposed a ban on opening of new maritime institutes and expansion of existing ones in 2012 to control quality of the institutes. The biggest impediment of ensuring quality has been shortage of training berths on ships for the students. Institutes that can provide adequate exposure to the students by providing training berths would be in great demand among the aspiring sea farers.

Enayam provides an opportunity to set up a best in class maritime education institute. South India is perceived as a major hub of talent for marine crew. There is a strong demand for marine education in the region. The institute can help cater to this demand. It will have an edge over other institutes due to the access it will get to the shipping liners who would operate in the Enayam port. This would allow the institute to provide adequate training berths to its students. The institute can also help develop Indian talent for other forms of shipping businesses like ship broking and maritime law, and can foster entrepreneurship in shipping services among others.

Innovation and R&D centres have been the backbone of maritime clusters across the world including the likes of Singapore and Norway. Norway had started the Norwegian Maritime Knowledge Hub- a collaboration among Norwegian University of Science and Technology, Norwegian Shipowners

Association and Norwegian government to gain competitive edge on shipping technology. Enayam is suited to become a site for a similar maritime knowledge hub through a research & development centre. The R&D and education hubs can prove to be a stepping stone for development of services hub in the region.

7. SITE INVESTIGATION STUDIES

7.1. MET-OCEAN DATA

7.1.1. Introduction

The aim of this section is to define the wave climate in coastal areas at certain locations near the area of study. To design the port structures, the offshore wave climate and its propagation to shallow water areas must be characterized.

The most important objectives are:

- Characterization of the offshore wave climate by analyzing the reanalysis databases from 1950 – '14
- A maximum dissimilarity selection algorithm (MDA) is applied in order to obtain a representative subset of sea states in deep water areas. The reduced number of selected cases spans the marine climate variability, guaranteeing that all possible sea states are represented and capturing even the extreme events.
- These sea states are propagated using a wave propagated model (SWAN) to shallow water areas.
- The time series of the propagated sea state parameters at a particular location are reconstructed using a non-linear interpolation technique based on radial basis functions (RBFs).
- Characterization of wave climate in shallow water at a particular location.

7.1.2. Data Sources

Wind, wave and tide data is obtained through third generation hindcasting models named Climate Forecast System Reanalysis (CFSR), for winds, and WaveWacth 3 (WW3) for waves. The following sections give further information on each:

- Winds

The Climate Forecast System (CFS) is a model representing the global interaction between the Earth's oceans, land, and atmosphere developed by the US National Centers for Environmental Prediction (NCEP). It is a global third generation reanalysis product. The CFSR is a high resolution, coupled atmosphere-ocean-land surface-sea ice system designed to provide the best estimate of the state of these coupled domains over the period from 1979 to 2010 (Saha et al., 2010).

The Climate Forecast System Reanalysis (CFSR) is an effort to generate a uniform, continuous, and best-estimate record of the state of the ocean-atmosphere for use in climate monitoring and diagnostics. CFSR stands out by its high resolution and advances in data assimilation techniques. Here, the near-surface winds from CFSR are freely provided.

- Waves:

The wave generation is obtained by using the WW3 model and the NCEP/NCAR global wind and ice cover databases. In order to check the performance of the wave generation model and the quality of the forcing fields, a preliminary validation is done using satellite altimetry data. Next stage consists of the calibration of the numerical results using satellite altimetry data.

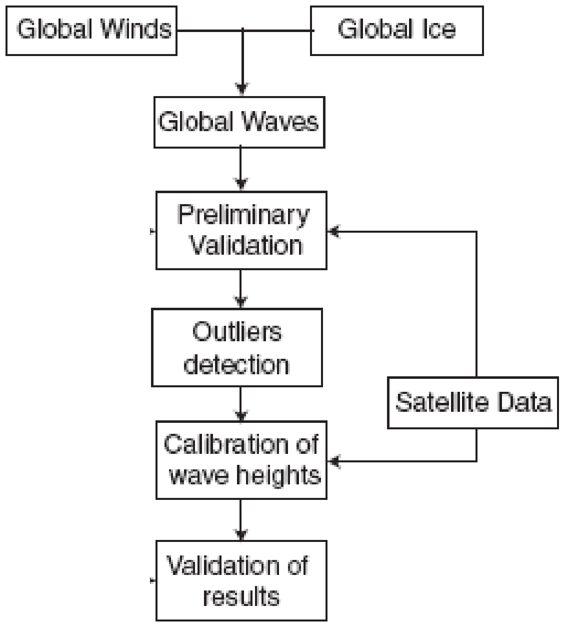


Figure 91: Methodology diagram.

Wavewatch III (WWIII, Tolman, 2002) is a third generation wave model developed at NOAA-NCEP. WWIII solves the spectral action density balance equation for wave number direction spectra.

More than 60 years of historical wind-generated offshore waves were performed for the last half century. The wave hindcast outcomes provide hourly time series of significant wave height, mean wave period, peak frequency and mean wave direction for all the grid points of the computed grid.

- Tides

GOT dataset provide hourly time series of astronomical tide for a selected period. It is generated using the harmonic constants derived from the TPXO7.0 global tides model developed by Oregon State University (http://volkov.oce.orst.edu/tides/global.html).

The database includes eight primary constants (M2, S2, N2, K2, K1, O1, P1, Q1), two long period constituents (Mf, Mm), and 3 non-linear (M4, MS4, MN4) harmonic constituents, provided in a global grid of 1440 x 721 points, at 1/4 degree resolution full global grid. This information is used to reconstruct hourly time series of tide in any location worldwide using the tool t_tide (Pawlowicz et al., 2002).

7.1.3. Reanalysis databases

This information has been extracted from two points with hourly temporal resolution:

Southwest India [Lon=76.50°E, Lat=8.00°N]

Southeast India [Lon=78.00°E, Lat=8.00°N]

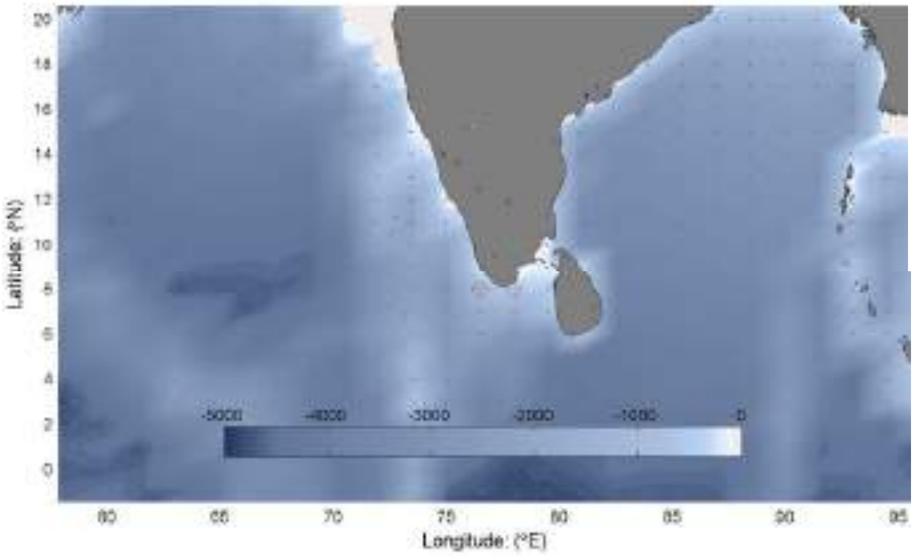


Figure 92: Location of the two points of met-ocean data

The met-ocean information consists of hourly time series of the following parameters of the sea state, wind speed and wind direction and sea level variability due to tide:

- Hs: Significant wave height (meters)
- Tm: Mean wave period (seconds)
- Fp: Peak frequency (Hz). Calculated from the one-dimensional frequency spectrum using parabolic fit around the discrete peak
- θ_{Hs}: Mean wave direction (degree., meteorological convention)
- W: wind speed at 10 meters above the sea surface (m/s)
- Wdir: Wind direction at 10 meters above the sea surface (degree., meteorological convention)
- Tide: tidal level (m) without meteorological effects/storm surge

7.1.4. Wind climate

Two offshore databases are available - one is on the western side and the other on the eastern side of the area of study. Each one has been explained below:

7.1.4.1. Western location

On the western side all wind directions are represented by the wind rose. This figure represents the wind speed, the wind direction and the frequency of occurrence from 1979 to 2010.

In conclusion the predominant directions in these 31 years are west and northwest.

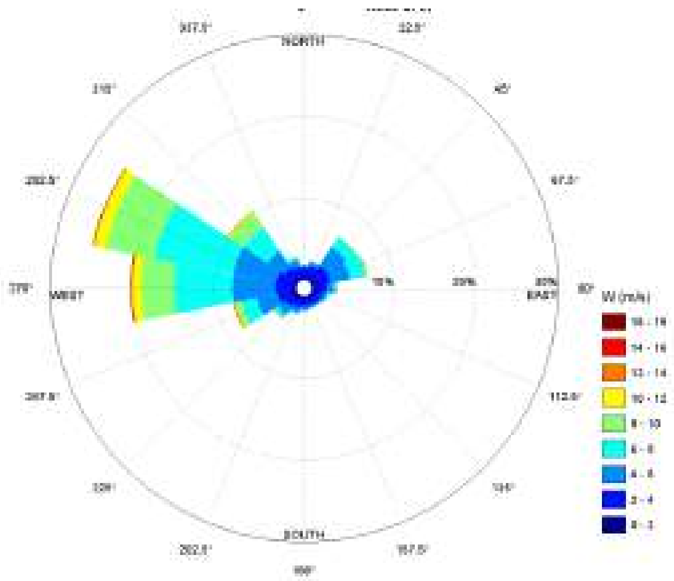


Figure 93: Western location wind rose

A study of winds has been done during the monsoon period, from June to September, and no monsoon period.

The predominant wind direction during the monsoon period in the western location is west to north-west. On the other hand during the non-monsoon periods, the predominant wind direction is from north-east during the morning and west during the evening. The maximum wind speed observed was of the order of 18m/s from westerly direction.

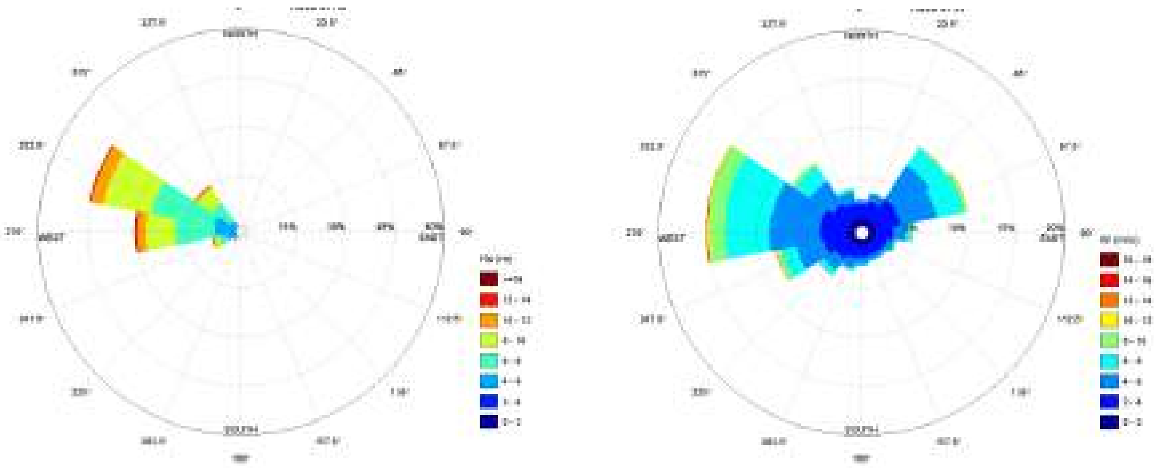


Figure 94: Winds in the monsoon period (left) and in the non-monsoon period (right)

7.1.4.2. Eastern location

A similar study has been done on the other data location; East point differs between monsoon period and no monsoon period. The figure below represents the global wind information from 1979 to 2010.

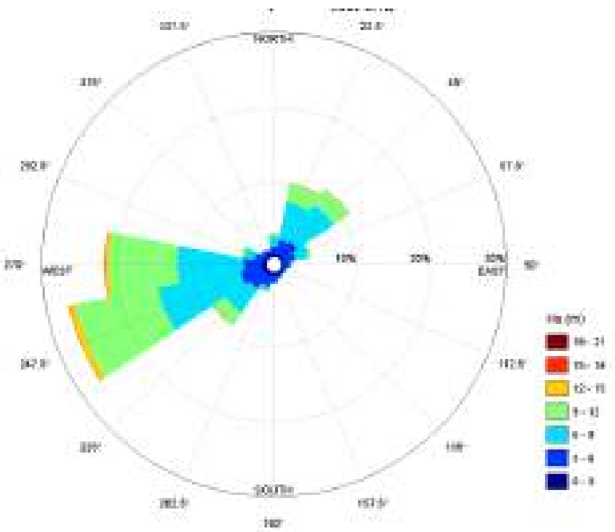


Figure 95: Eastern location wind rose

The predominant wind direction during the monsoon period in the eastern location, from June to September, is west to south-west. On the other hand during the non-monsoon periods, the predominant wind direction is from north-east during the morning and west during the evening.

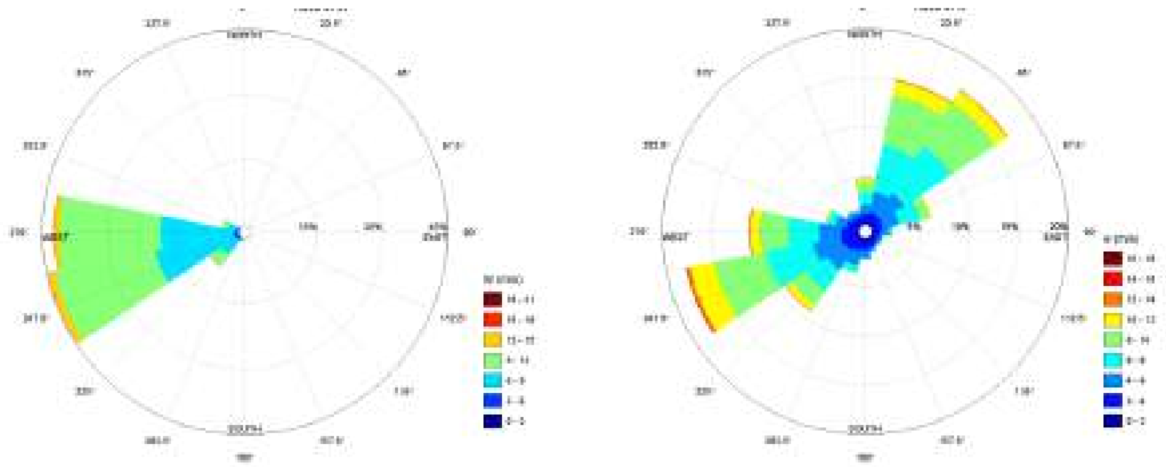


Figure 96: Winds in the monsoon period (left) and in the non-monsoon period (right)

7.1.5. Sea level

The information available of sea level provides hourly time series of astronomical tide data for a selected period (from 1950 to 2014).

Tide information is measured with respect to the Mean Sea Level (MSL). This data have been transformed taking the lowest astronomical tide as the zero value of the tide information, the transfotmation is shown in the below figures. The table below shows the sea levels:

Sea level	Description	Value
HAT:	Highest Astronomical Tide. The elevation of the highest predicted astronomical tide expected to uccur at least once a year	1.05 m
HHWS	Highest High Water Spring	1.04m
MHHW	Mean Higher High water. The mean of the higher of the two daily high waters over a long period of time. When only one high water occurs on a day, this is taken as a higher high water .	0.83m
MLHW	Mean Lower High Water. The mean of the lower of two daily high waters over a long period of time. When only one high water occurs on a day, no value is printed in the MLHW column, indicating that the tide is diurnal .	0.67m
MHLW	Mean Higher Low Water. The mean of the higher of the two daily low waters over a long period of time. When only one low water occurs on a day, no value is printed in the MHLW column, indicating that the tide is diurnal.	0.41m
MLLW	Mean Lower Low Water. The mean of the lower of the daily low waters over a long period of time. When only one low water occurs a day, this is taken as the lower low water	0.25m
LLWS	Lowest Low Water Spring	0.02m
LAT	Lowest Astronomical Tide. All heights have been taken above the lowest astronomical tide	0.00m
GT	Great Diurnal Range The difference in height between mean higher high water (MHHW) and mean lower low water (MLLW).	0.58m

Table 14: Sea levels

7.1.6. Wave climate

7.1.6.1. Deep water wave climate

A brief description is represented by wave roses in each location. In summary, the dominant waves come from the south-south western direction.

These figures represent the wave height, wave direction and the frequency of occurrence from 1950 to 2014.

- Western location wave rose

  The predominant wave direction is from south to south-southwest, but the highest ones come from the south west to the west.

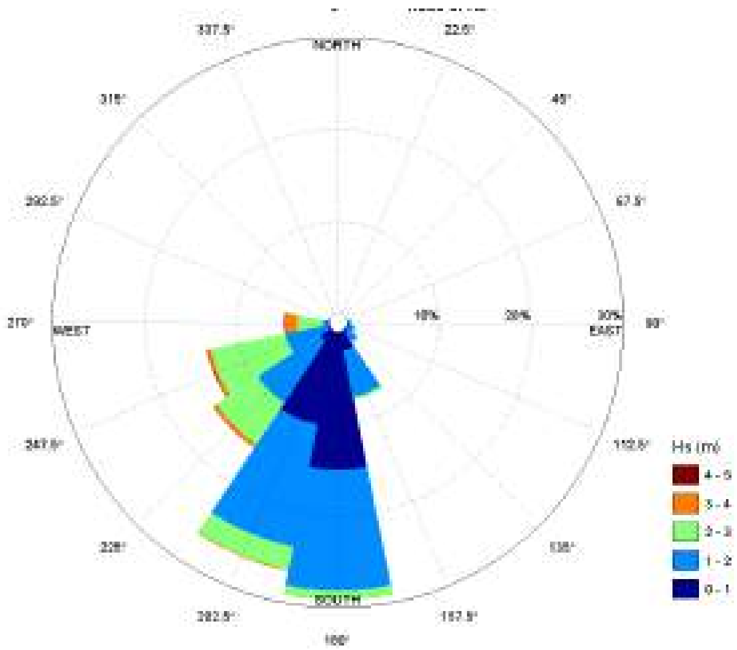


Figure 97: Western location wave rose.

During the monsoon period, the predominant directions are western-south western and south western.

The biggest waves come from the west, with a height of 4-5 meters. And during the non-monsoon periods, the predominant wave directions are south and south-southwest. This can be seen in the below figure

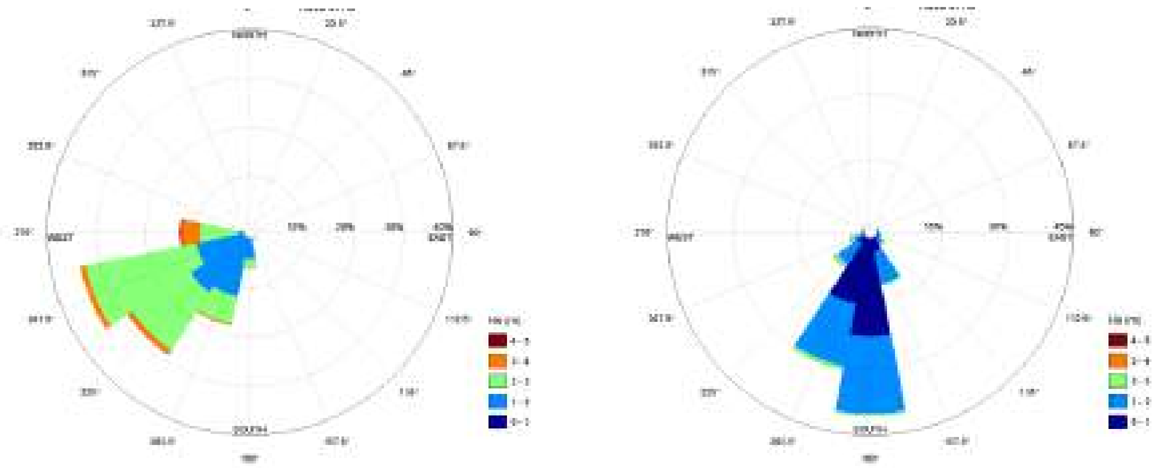


Figure 98: Waves in the monsoon period (left) and in the non-monsoon period (right)

- Eastern location Wave Rose

The same study has been done in the other location point. The below figure represent the height wave, wave direction and frequency of occurrence in eastern location from 1950 to 2014.

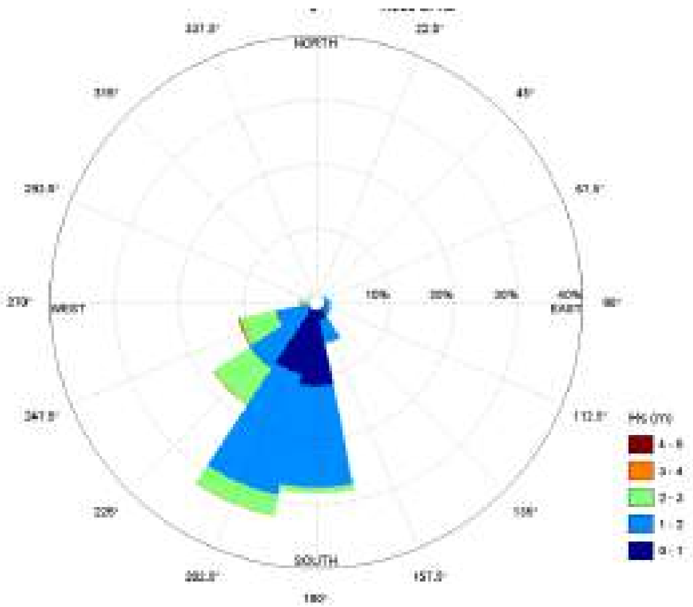


Figure 99: Eastern location wave rose.

The information is approximately the same as in the western location, the predominant direction being from south to south-southwest all year round. The predominant direction is southwest during the monsoon period and south and south-southwest during the non-monsoon periods.

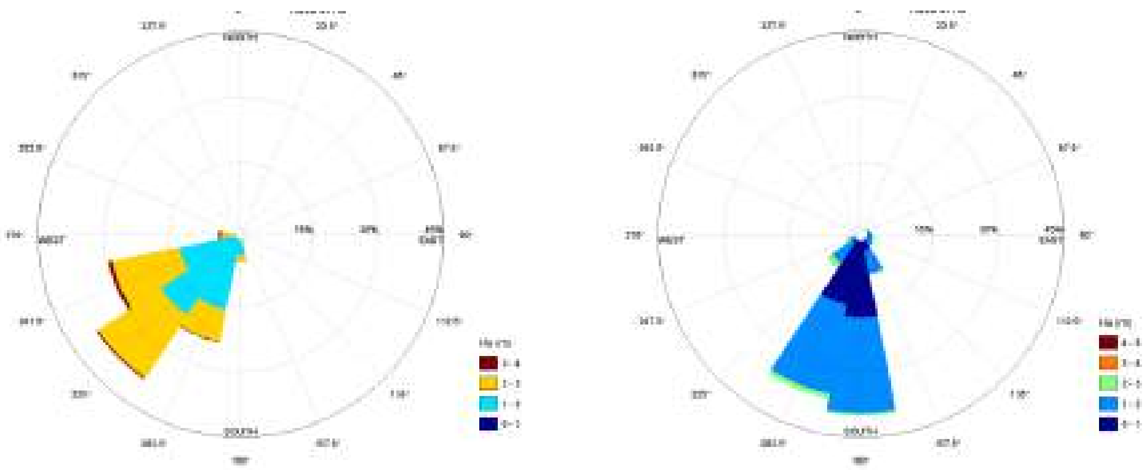


Figure 100: Waves in the monsoon period (left) and in the non-monsoon period (right)

- Mean and extreme regime

The Mean regime of time series is the set of sea states that have more probability of occurrence. The following figures show the long-term distribution of significant wave height (Hs) in mean regime probability in each location:

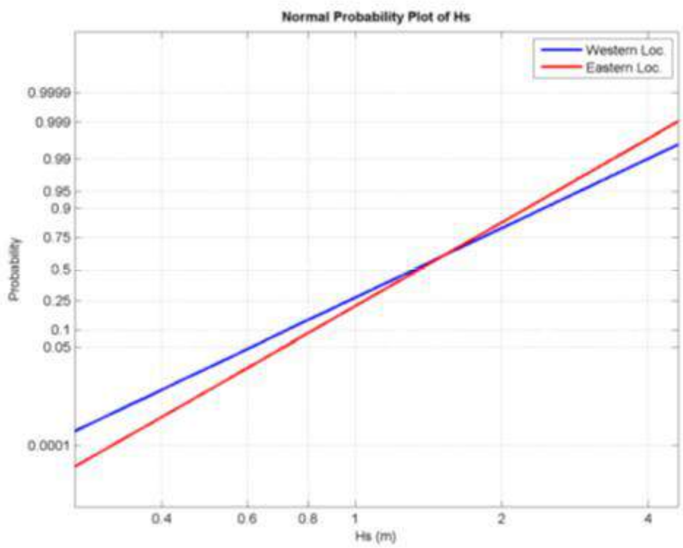


Figure 101: Wave mean regime in the western and eastern locations

The security and operability of port structures are conditioned by wave action in a storm situation.

With the aim of reduce the risk that port structures can suffer because of wave action, is important to know an estimation of the frequency which a storm with a higher wave height could be presented

The extreme regime is a statistic model that describes the probability that a storm can appear with a certain wave height. This is showed in the figure below:

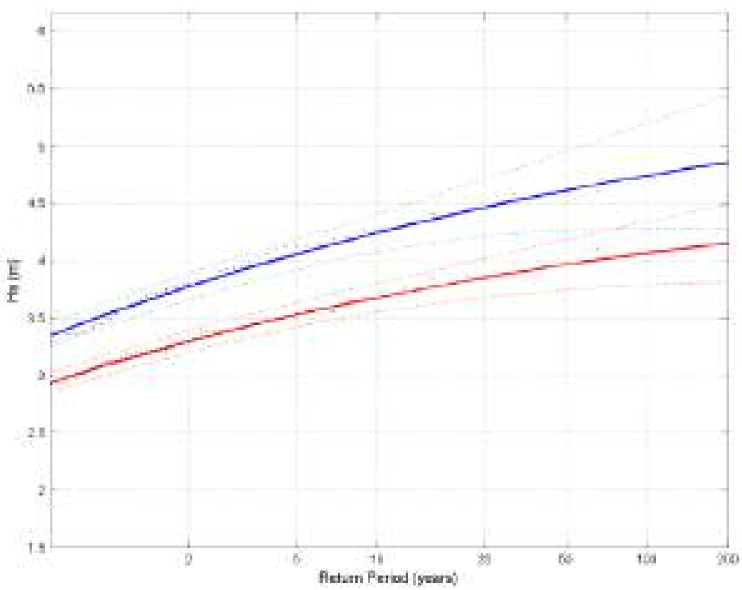


Figure 102: Wave extreme regime in the western and eastern locations

7.1.6.2. Wave transformation from deep waters to shallow waters

As a first step, a selection process is used to extract a subset of wave situations which represent the available ocean conditions from the reanalysis database.

These sea states are propagated using to shallow water areas in different points of interest in which one-time series of wave parameters will be reconstructed.

The propagation model used for it (SWAN) consists in a numerical approximation of waves from deep water to shallow water near the coast in order to evaluate the variability of the wave climate.

The bathymetry of the area of study and the orientation of the coast with respect to the incident waves are both decisive for the most relevant phenomenon that affects the wave in each particular case.

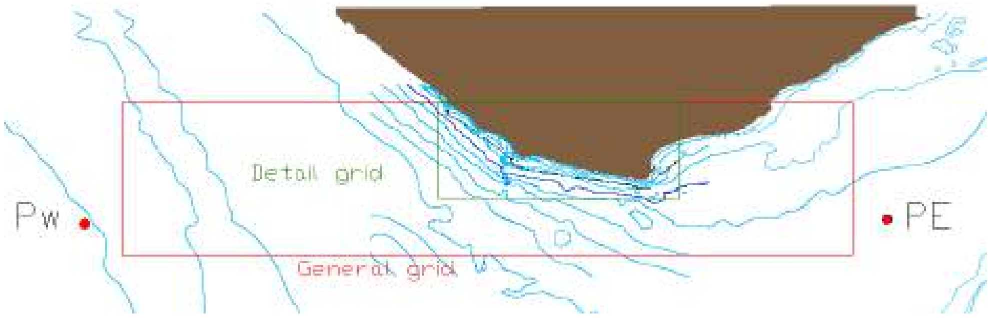


Figure 103: General grid (red line) and detail grid (green line)

A number of points of interest are located near the coast (P1, P2... P21).

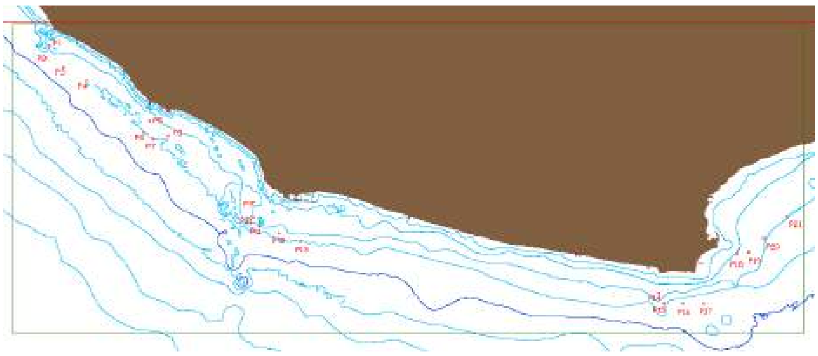


Figure 104: Analyzed points in shallow water along the coast

The reconstruction of the time series of wave parameters at near shore is carried out using an interpolation technique based on radial basis functions (RBFs). The time series are transferred from deep water to the points of interest at shallow water by means of the RBFs functions calculated for each propagated parameter.

The RBF technique has proven to be a powerful technique to reconstruct time series of sea state parameters for each sea state at deep water.

7.1.6.3. Shallow water wave climate

When the reconstruction of the time series of wave parameters at the near shore points are carried out, the characterization of wave climate in shallow points can be done.

One point near shore has been taken in this section in order to explain the characterization in shallow water, because the behaviour of the 17 points near shore is very similar.

The below pictures represent the height wave series in a period of time, as can be seen in the enclosed figure, there are few height wave over 4.5 meters.

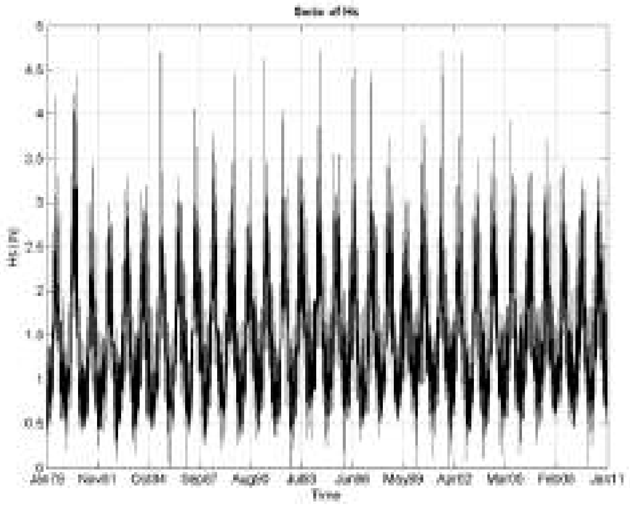


Figure 105: Series of significant wave (Hs)

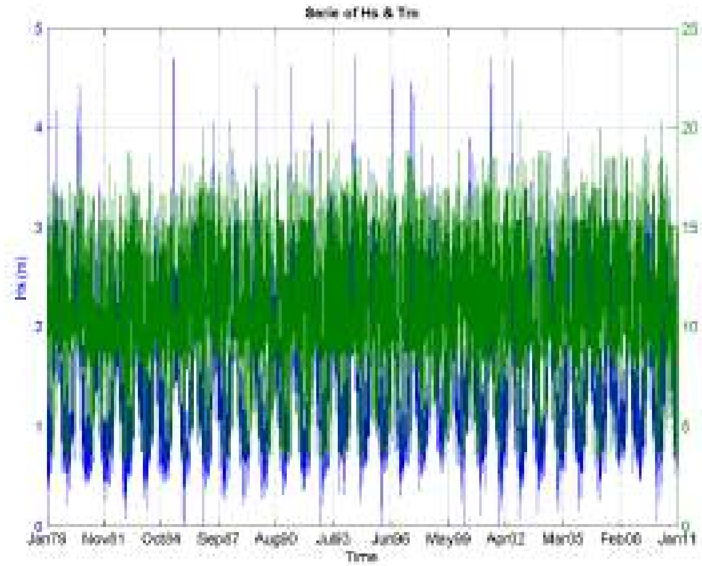


Figure 106: Series of significant wave (Hs) and peak period (Tp)

Wave roses

Wave roses represent wave height, direction wave and frequency of occurrence, all of them are very similar in all points, and the main direction to everyone is from the southwest.

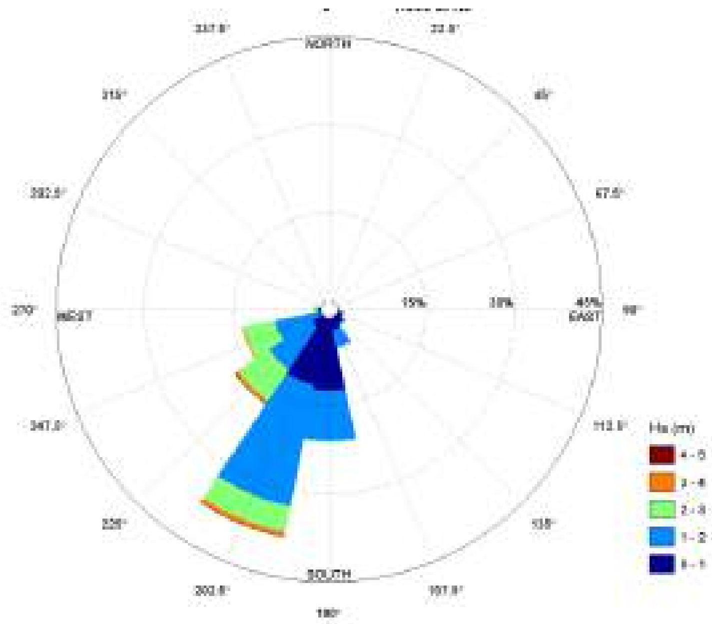


Figure 107: Wave Rose

Extreme regime

The Extreme regime is represented in this figure for one of the propagated points. For 200 years of return period a wave height of 5 meters is obtain, as is shown in the below picture:

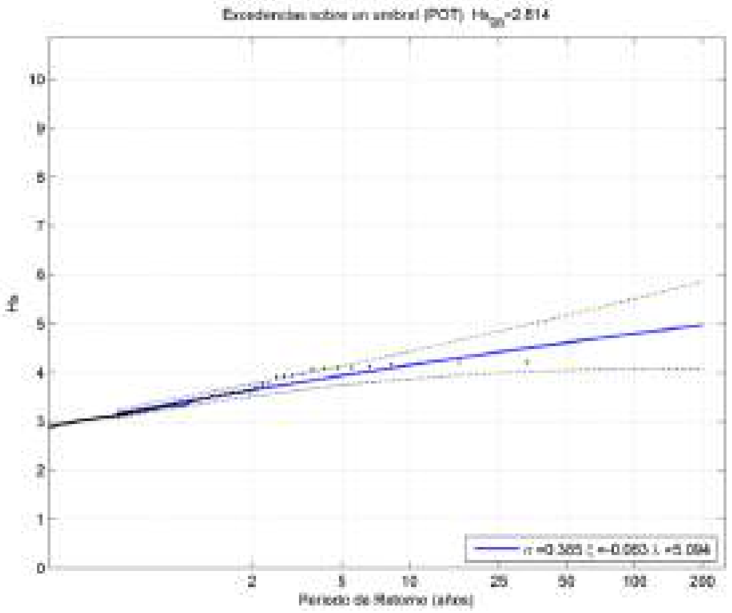


Figure 108: Wave heights and return periods

In conclusion, knowing the predominant wave direction, the wave height for 200 years of return period and the peak direction associated to this wave height is necessary for designing the port structures (rubble-mound breakwater and vertical breakwater).

To sum up, the dominant waves come from the south-south western direction, and for 200 years of return period, a wave height of 5 meter with a peak period of 11,5 seconds have been taken for the preliminary design of port structures.

More detailed information of this study is enclosed in Annexure 3: Metocean analysis - Wave propagation.

7.2. BATHIMETRIC DATA

In order to have good bathymetric information of all the possible locations, a series of nautical charts -both in paper and electronic (ENC) - have been purchased through MaxSea TimeZero software.

Specifically, the following charts have been used:

- 2048-Kolachel Anchorage (1:30,000)
- 222-Quilion to Colachel (1:150,000)
- 223-Colachel to Manappad (1:150,000)
- 7365-Cape Comorin to Pamban (1:300,000)
- 7362-Cochin to Cape Comorin (1:300,000)

A complete bathymetric map has been developed combining all the charts, leading to a chart like the following (see drawing-01 for more detailed info).

Figure 109: Bathymetry plan of Enayam coast

7.3. TOPOGRAPHIC DATA

Topographic information has been extracted from various sources like Google Earth through PlexEarth, specialized software which have been purchased by the Consultant for this purpose. This information has been completed using the available land charts of the region. The following figure shows the result of the processing of information:

Figure 110: Topographic plan of the studied area

7.4. GEOLOGY AND GEOTECHNICS

7.4.1. Introduction

The aim of this section is to describe the geological conditions of the port location and evaluate the geological, geotechnical and seismic risks that may affect the development of the correspondent project.

The report is based on the available geological data and the existing geotechnical reports in the vicinity of Colachel, and specifically:

- Hydro-geological Studies along the Coastal Area of Kanyakumari to Colachel after Tsunami, South Tamil Nadu. S.Bhagavathi, P.Thamarai and L. Elango. 2010.
- Groundwater Quality assessment And Regional Flow Modelling of Kanayakumari Colachel Coastal Aquifer, Tamilnadu, India. S.Bhagavathi Perumal. 2008.
- "Geophysical Survey for Vizhinjam Deep Water International Transshipment Terminal Kerala Off-Shore, West Coast of India (Fugro, July 2011).
- Geotechnical Data included in the "Detailed Project Report. Development of Vizhinjam Port" (AECOM, May 2013).

7.4.2. Description of the regional geology

All the proposed locations are placed in the Tamil Nadu region, affected by intense metamorphism. Geologically, Tamil Nadu is divided into three zones: the northern region, the southern region and the central region. Colachel Port is located in the southern region.

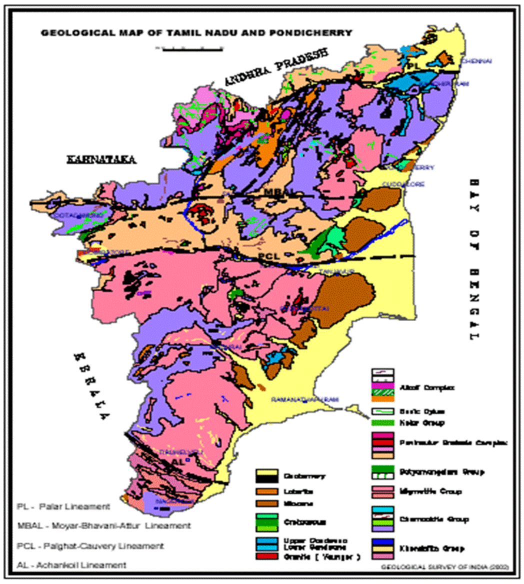


Figure 111: Geological map of Tamil Nadu (Source: *http://www.tnmine.tn.nic.in*).

According to the information provided by the Department of Geology and Mining of the local government, the southern region is characterized by the following geologic events and rocks:

- They can be found south of the Palghat-Cauvery tectonic zone.
- In the western area of this zone, charnockites form the massifs of the Western Ghats, and gneisses are predominant along the eastern part.
- This region differs from the northern and central regions for the predominance of meta-sedimentary rocks such as quartzites, sillimanite quartzites, calc-granulites, garnet and cordierite bearing meta-pelites.
- This zone is totally devoid of dolerite dykes and banded magnetite quartzites.
- In the northern part of this region, calc-silicates and crystalline limestone occur as thick sequences with a few tens of metres of thickness.
- Extensive limestone deposits are found from Palayam to Kiranur, Rajapalayam-Alangulam belt east of the Varshanad hills and Talaiyuthu, near Tirunelveli.
- At the southern end of the Indian peninsula and to the south of the Achankoil shear zone, the terrain consists of garnet-biotite-graphite gneisses, garnetiferous charnockite, khondalites (garnet-sillimanite-biotite-graphite) and cordierite gneiss.

The basement of the Kanyakumari District coastal belt, where the port area is located, consists of charnockite, granite gneiss, leptinite gneiss, peninsular gneiss, laterite and warkalai sandstone. There are several indications of numerous episodes of deformation, which caused repeated folds, faults, joints and fracture systems. The basement rocks are overlain by red soil, lateritic soil, llayey soil, river alluvium and coastal alluvium, black, red and red sandy soil of thickness ranging from 1 m to 1.5 m in most places.

7.4.3. Description of the site

This site is located to the northwest of the coastal belt. The basement consists of garnetiferous biotite gneiss. The general trend of the strike in this area is N-NW to S-SE.

Some rocky islets are observed around 500 meters away from the coastline. Besides, weathered rock has been identified close to the surface below laterite and beach sands.

These signs seem to indicate that the rock basement is relatively close to the surface and onshore soil thickness is small, although 3.5 kilometres to the northwest, the Tambraparna River flows towards the Indic Ocean, and the long-shore drift transports sands to the Enayam location.

Figure 112: Rocky islets near the beach (left) and weathered rock below the laterite soils (right).

7.4.4. Seismic hazard

The proposed project falls under Seismic Zone III, according to the classification proposed at IS 1893 (Part I): Criteria for earthquake resistant design of structures. The zone factor Z which corresponds to Zone III is 0.16.

Figure 113: Seismic zone map. Source: Geological Survey of India (GSI).

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Table 15: Zone factor Z value. Source: IS 1893 (Part 1) : 2002.

7.4.5. Estimated subsoil profile

In order to develop an initial design for dredging works and foundations, a preliminary soil profile has been estimated based on the site visits and the geological and geotechnical data given in 7.4.1.

The subsoil profile has been assumed as follows:

- Loose to medium dense sand from seabed to 5 m below seabed
- Medium to dense sand from 5 m to 15 m below seabed
- Moderately strong rock from 15 m below sea bed

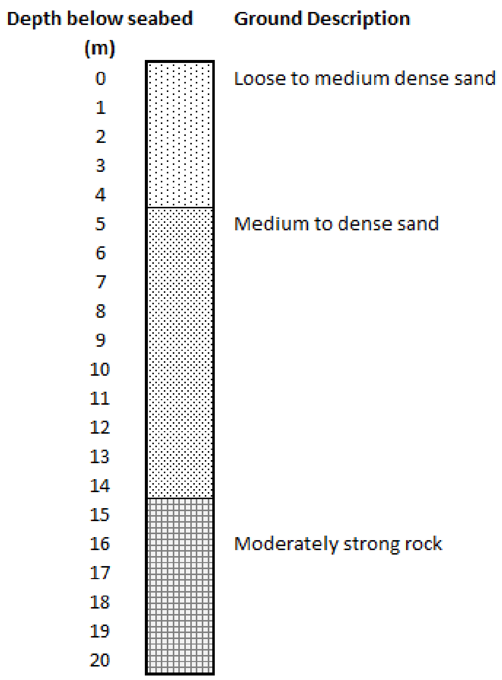


Figure 114: Preliminary soil profile assumed for the feasibility design

It is important to clarify that this soil profile is only a preliminary estimation, and must be reviewed by a proper geophysical and geotechnical study. Particularly, the field investigation shall include, at least, information from side scan sonar, sub-bottom profiler, boreholes, soil samples and laboratory tests.

It is also important to note that the bedrock surface is expected to be uneven, since the weathering of gneiss tends to create irregular profiles depending on the orientation and characteristics of the discontinuities. Among others, this fact can influence the geotechnical design of pile foundations (the total pile length will vary with the specific location of the rock).

Thus, the proposed profile must be assumed just as a first approach of the average geotechnical conditions at the site, to be confirmed in further phases of the project.

7.4.6. Geotechnical risks

From a geotechnical point of view, the main risks to be considered in further stages of the project can be summarized as follows:

- Presence of rock or hard materials in the area to be dredged, which would involve an important impact on the cost and performance of the dredging works.
- Presence of soft or very loose materials in the locations of breakwaters, berths, or earthfills, which may require special foundations or ground treatments to guarantee the structural requirements.
- Steeply sloping seafloors and accompanying down-slope soil movements can cause additional lateral pile forces in the down-slope direction. Also, steep sloping makes the area more vulnerable to instability induced by the seismic activity of wave forces.
- Scouring of near-surface soils can occur and can be accentuated in the vicinity of piles. The extent of the scouring depends on the velocity of seafloor currents, the type of soil and the size and configuration of pile groups.
- Earthquake-related hazards should be assessed in seismically active areas. Earthquake motions may cause partial loss of strength or complete liquefaction in loose granular soil zones, essentially removing soil support developed in these zones.
- Gneisses are more susceptible to weathering compared to massive charnockites. Erosion in gneiss areas is higher than in charnockite areas, therefore rivers in gneiss areas are prone to transporting more sediments than those in charnockite areas.

The table below shows a general assessment of the geotechnical risks described above. More detailed analyses should be developed in further stages of the project, based on the results of the geotechnical field investigation (boreholes, trial pits, geophysical profiles, etc.).

	% rock near surface	Thick deposits of sediments	Steeply sloping seafloor	Type of rock (weather susceptibility)
Grade	Low	Low	Low	Moderate

Table 16: Geotechnical risks.

7.5. LAND AVAILABILITY

As the port is to be developed entirely on reclaimed land, no land acquisition is envisaged for the port development. However, the project shadow area can impact fishermen dwellings.

Coastal land from Colachel to Enayam would change to a port area. As a result of the Project development, this part of the sea coast and beaches would be permanently lost during the construction and operation of the Project.

However the port being an international facility with multitude of infrastructure planned, the port could also require backup areas in the immediate vicinity. Following images show the current land-use and population within the 2.5x3.00 Km square area close to port location.

- Affected land and properties

To carry out a description of the land use in areas near Enayam a rectangular area of 2 x 3 km surface was determined as the "scope area". Polygons with similar characteristics were grouped and classified. The scale of work to determine the polygons was 1: 2,500.

After the completion of this work, the land uses in the Enayam "scoping area" are:

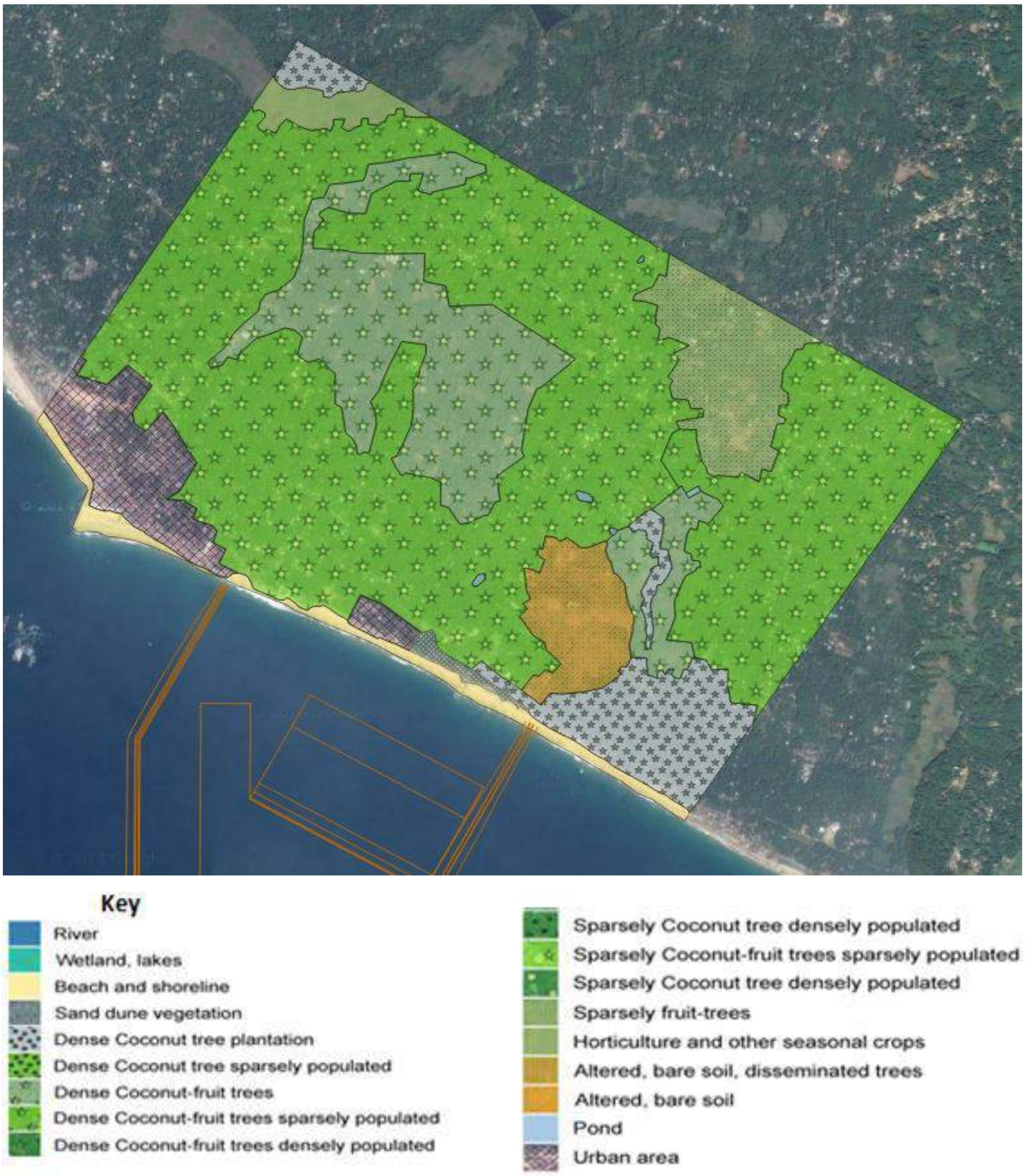


Figure 115: Enayam Port Area Land-Use Map

- Population Affected

The following image shows in-land population density close to the port area:

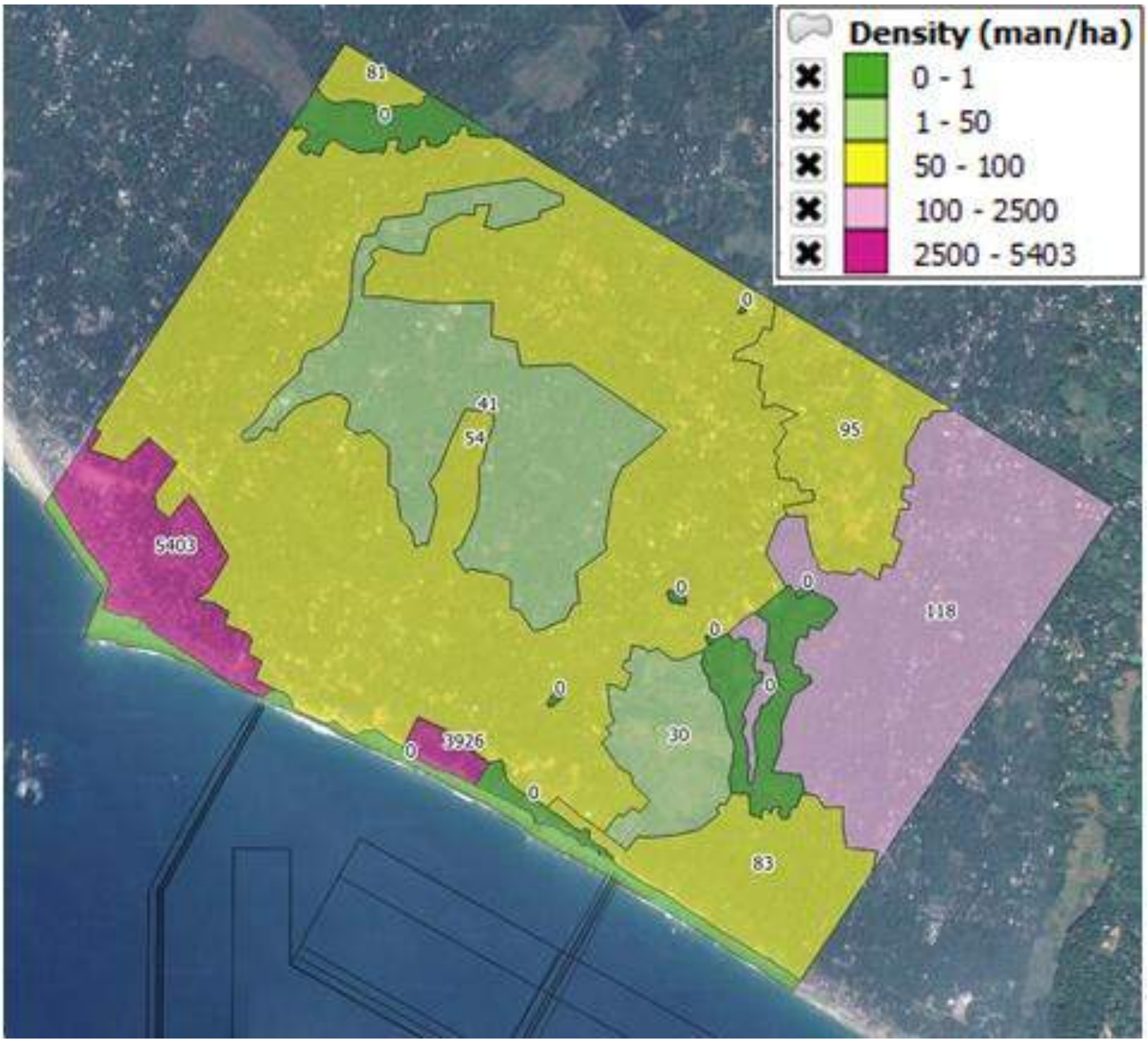


Figure 116: Enayam Port Area Population Density Map

- Estimated land rates

Land surface data and reference rates for the identified use, obtained from local real estate companies, field works and surveys (polls) and internet specialized websites, are the following.

Use	Lacs/acre
Beach and Shoreline	-
Sand Dune Vegetation	0.20
Dense Coconut Tree plantation	30
Dense Coconut - Fruit Trees	20
Sparse Coconut - Fruit Trees sparsely populated	10
Arable Crops	5
Sparse Fruit Trees	10
Altered, bare soil, disseminated trees	1
Pond	-
Urban area 1	8
Urban area 2	3

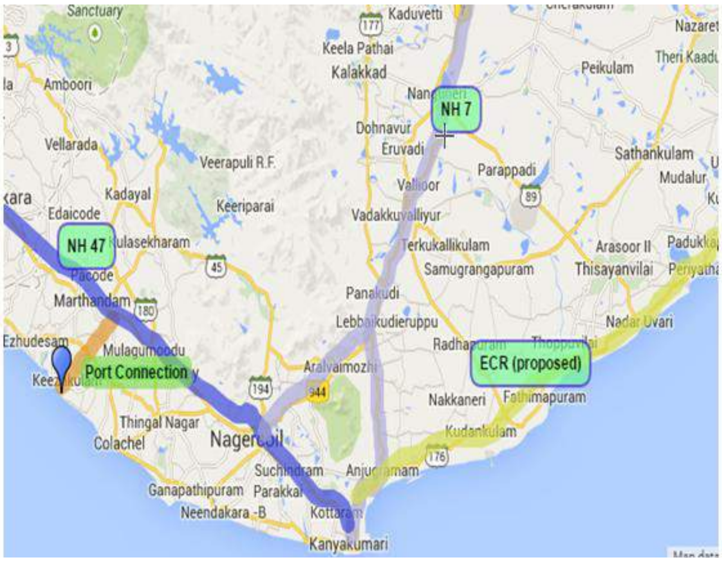
7.6. TRANSPORT LINKAGES

7.6.1. Road links

The closest main road to the port is the National Highway NH47, which connects Nagercoil and Thiruvananthapuram. It is about 10 km from the coastline as the crow flies. At present, it has two lanes (one in each direction) and it runs through numerous built-up areas, which means that traffic congestion is quite normal. A tender to build a new four-lane highway that will run parallel to this road is expected in the short term.

The National Highway NH7 is the road that connects by road the west coast of Tamil Nadu State –where the port is located- to the rest of the State of Tamil Nadu. The traffic on this four-lane highway runs smoothly.

A new road is also due to be built along the eastern coast of Tamil Nadu, which may well improve connectivity with the production centres in the hinterland.



As far as the zone closest to the port is concerned, in the stretch of land between this area and the NH47 there are many minor roads that connect the various towns that are found there. There are also numerous access roads to plantations and housings.

7.6.2. Rail links

The closest railway line is the one that connects Kanyakumari in the south to the State of Kerala in the north. This single broad gauge track runs approximately 9.5 km from the place in which the port is envisaged. This is the line the port will have to connect to, if cargo is to be brought in by rail.

There is also a single track that runs from Nagercoil towards the rest of the State of Tamil Nadu, which would facilitate the connection to the port's area of influence. It is expected that a second track will be added in the near future.

8. DESIGN CRITERIA

8.1. TRAFFIC AND PHASING

The Traffic and Market Study summarized in earlier provides an estimate of Colachel's trans-shipment and gateway traffic under multiple scenarios. It also explains in detail the factors that may substantially impact the traffic movements. Besides, the report provides traffic estimation for bulk (coal) traffic.

The conclusions drawn in the aforementioned study for the Base Case, which is the selected one to design the port facility, is shown in the table below:

Base Case	units	2018	2020	2025	2030	2035	2040	2045
Bulk Traffic	in Mn MT	-	-	3.3	6.6	9.9	9.9	9.9
Container - Gateway	in Mn TEU	0.6	1.0	2.1	2.9	3.9	5.0	6.2
Container - Trans-shipme	in Mn TEU	0.4	0.7	2.8	3.9	5.2	8.0	11.5
Total	in MN MT	15.4	26.2	79.4	111.1	151.2	210.6	284.1

Table 17: Traffic estimates for Base Case

Three phases have been defined to size the berths and operational area of the port, which lead to:

- Phase 1: From 2018 (beginning of operations) to 2020. The facilities will be defined to cater the forecasted traffic for 2020.
- Phase 2: From 2021 to 2025. The facilities will be defined to cater the forecasted traffic for 2025.
- Phase 3: From 2026 to 2030: The facilities will be defined to cater the forecasted traffic for 2030..

Although a forecast for traffic has been made for years 2030 to 2045, planning a facility for such a long period is very risky. Many of the factors which have been used on the traffic study and nowadays are considered valid may change in the future. In any case, the port facility will be designed to be easily expandable beyond the 2030 traffic forecast.

According to this phasing, the expected traffic volume for each phase is presented below.

	Units	Phase 1 (2020)	Phase 2 (2025)	Phase 3 (2030)
Bulk traffic (coal)	M. Ton	0.00	3.30	6.60
Container traffic (total)	M. TEU	1.70	4.90	6.80

Table 18: Estimated traffic for each phase

Although no estimations have been made for other traffic, some general cargo, liquid bulk or solid bulk are expected to be attracted by the new port.

8.2. TECHNICAL CRITERIA

8.2.1. Design Vessel

In order to design the berths, basin size and draft, two large vessels have been taken:

Vessel Type	Tonnage (DWT)	Displacement (t)	Length (m)	Beam (m)	Draft (m)
VLCS (Container ship)	18,000 TEU	260,000	400	59	16
Capesize (Bulk Carrier)	120,000	145,000	270	43	16
Capesize (Bulk Carrier) (1)	150,000	177,000	294	45.9	17.5

Table 19: Vessels main figures

(1) The 150.000 DWT Capesize bulk carrier will also be partially considered for the Phase 1 dredging because, although it is not expected in the near future, it could be expected to call the port in next phases of the port.

8.2.2. Wave heights

The wave height for planning will be:

- Mean regime Significant Wave Height (Hs): That is the set of sea states that have more probability of occurrence, and it is described by the highest third of the waves ($H_{1/3}$). For the project site, Hs is considered 2.0 m. More details from design criteria can be extracted from occurrence tables, for example predominant wave direction, peak period associated with different wave heights and their probability of occurrences, etc. All this information is shown in the below tables.

		Hs (m)										
		0.00 - 0.50	0.50 -1.00	1.00 - 1.50	1.50 - 2.00	2.00 - 2.50	2.50 - 3.00	3.00 - 3.50	3.50 - 4.00	4.00 - 4.50	4.50 - 5.00	**Total**
Tp (s)	2.00 - 3.90	0.21	0.12	0.02	0.01							**0.35**
	3.90 - 5.80	0.89	0.77	1.52	0.18	0.00	0.00					**3.35**
	5.80 - 7.70	0.16	0.60	0.95	1.55	0.21	0.02					**3.50**
	7.70 - 9.60	0.63	8.43	6.01	6.19	1.94	0.14	0.01				**23.35**
	9.60 - 11.50	0.70	7.51	7.41	7.32	6.03	1.06	0.03				**30.05**
	11.50 - 13.40	0.53	7.63	7.05	2.53	1.53	0.30	0.02				**19.58**
	13.40 - 15.30	0.17	4.62	5.33	2.77	1.76	0.51	0.14	0.02			**15.33**
	15.30 - 17.20	0.01	0.89	1.13	0.92	0.68	0.21	0.08	0.07	0.01		**3.99**
	17.20 -19.10		0.11	0.10	0.14	0.09	0.03	0.01	0.02			**0.49**
	19.10 - 21.00		0.01	0.01	0.00	0.00	0.00					**0.03**
Total		**3.29**	**30.68**	**29.52**	**21.60**	**12.23**	**2.28**	**0.29**	**0.11**	**0.01**	**0.00**	**100**

Table 20: Occurrence table (Hs(m)&Tp(s))

		Hs (m)										total
		0.00 - 0.50	0.50 -1.00	1.00 - 1.50	1.50 - 2.00	2.00 - 2.50	2.50 - 3.00	3.00 - 3.50	3.50 - 4.00	4.00 - 4.50	4.50 - 5.00	**280506.00**
DD (º)	0.00 - 35.80											**0.00**
	35.80 - 71.60	0.02										**0.02**
	71.60 - 107.40	0.20										**0.20**
	107.40 - 143.20	0.98	0.42	0.03	0.02							**1.44**
	143.20 - 179.00	0.33	4.39	2.98	0.32	0.02						**8.02**
	179.00 - 214.80	1.55	22.30	18.48	6.22	1.93	0.44	0.07	0.02			**51.02**
	214.80 - 250.60	0.18	3.31	7.63	13.32	6.85	1.30	0.22	0.09	0.01		**32.89**
	250.60 - 286.40	0.03	0.25	0.41	1.72	3.44	0.54	0.01				**6.39**
	286.40 - 322.20		0.01	0.00								**0.01**
	322.20 - 358.00											**0.00**
total	**280506.00**	**3.29**	**30.68**	**29.52**	**21.60**	**12.23**	**2.28**	**0.29**	**0.11**	**0.01**	**0.00**	**100.00**

Table 21: Occurrence table (Hs(m)&DD(º))

		Tp (s)										total
		2.00 - 3.90	3.90 - 5.80	5.80 - 7.70	7.70 - 9.60	9.60 - 11.50	11.50 - 13.40	13.40 - 15.30	15.30 - 17.20	17.20 -19.10	19.10 - 21.00	**280506.00**
DD (º)	0.00 - 35.80											**0.00**
	35.80 - 71.60		0.01									**0.02**
	71.60 - 107.40	0.03	0.17									**0.20**
	107.40 - 143.20	0.25	1.07	0.02	0.10							**1.44**
	143.20 - 179.00	0.01	0.10	0.22	4.46	2.25	0.65	0.28	0.05			**8.02**
	179.00 - 214.80	0.01	0.09	0.33	9.22	15.02	13.76	10.12	2.22	0.23	0.02	**51.02**
	214.80 - 250.60	0.04	1.51	2.33	7.41	9.71	5.02	4.91	1.72	0.26	0.01	**32.89**
	250.60 - 286.40	0.01	0.39	0.59	2.16	3.07	0.16	0.02				**6.39**
	286.40 - 322.20	0.01	0.01									**0.01**
	322.20 - 358.00											**0.00**
total	**280506.00**	**0.35**	**3.35**	**3.50**	**23.35**	**30.05**	**19.58**	**15.33**	**3.99**	**0.49**	**0.03**	**100.00**

Table 22: Occurrence table (Tp(s)&DD(º))

- Extreme regime: For preliminary design of main defence structures, mainly breakwaters, a Return Period (Tr) of 200 years has been taken. That is the wave height that occurs, as a mean value, only once each 200 years.

The table summarizes the values for the shallow water control points near the breakwater:

	Mean regime Hs (m)	Extreme regime(200 years) Hs (m)
Enayam breakwater	2.0	5.0

Table 23: Hs Mean Regime and Extreme Regime

8.2.3. Sea level

The tide levels are shown in the table below:

Sea level	**Description**	Value
HAT:	Highest Astronomical Tide. The elevation of the highest predicted astronomical tide expected to uccur at least once a year	1.05 m
LAT	Lowest Astronomical Tide. All heights have been taken above the lowest astronomical tide	0.00m

Table 24: Tide levels

These tidal levels have been obtained from the Databases of astronomical tide, and others heights have been add over the Highest Astronomical Tide as:

- Meteorological tide :

  From the Journal of Coastal Research non-tidal sea level has been obtained. This Professional Paper based on the sea level data measured at three locations along the nearshore waters of Karnataka, west cost of India. In conclusion Correlation between alongshore component of wind and non-tidal sea level was 0.54 m at Malpe and 0.48 at Honnavar. A 0.54 m storm surge has been considered.

- Expected Sea Level Rise:

  For waterfront structures over the port design life the sea level rise for 50 years is 0.38m according to IPCC (*Intergovernmental Panel on Climate Change* , Climate Change 2014 Synthesis Report), the table below shows the projected change in global mean sea level rise for the mid-and late 21st century:

		2046–2065		2081–2100	
	Scenario	Mean	*Likely* range [c]	Mean	*Likely* range [c]
Global Mean Surface Temperature Change (°C) [a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	Mean	*Likely* range [d]	Mean	*Likely* range [d]
Global Mean Sea Level Rise (m) [b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Table 25: Climate Change 2014 Synthesis Report, IPCC

The **design water level** for the breakwater design is=HAT+ Storm Surge (meteorological tide) + Expected sea level Rise = 1.05+0.54+0.38=**+1.97m**

8.2.4. Operability

In order to limit the downtime on the berth caused by environmental factors, and more specifically, by waves, the defence structures must be capable to limit the wave height at berth.

The following maximum wave heights have been considered for container berths:

- Hs= 0.3 m for waves coming transverse to the vessel.
- Hs= 0.5 m for waves coming longitudinal to the vessel.

9. DETAILED PORT CONFIGURATION

9.1. GENERAL

The design of the port's facilities is the direct consequence of the traffic that it is expected to be able to attract in the future. In this sense, container cargo is obviously the primary activity, followed by, in a second phase and as a secondary activity, coal cargo. The fact that the port may attract small amounts of other types of general merchandise has been also taken into account.

Breakwaters have been defined to protect the facilities from the wave action following the criteria described in earlier sections. Besides, it is important to mention that, due to the fast growth expected for container traffic, berths will be expanded two or three years after finalizing the construction of Phase 1. Therefore, it has been decided not to prolong the south breakwater beyond the berth line in order to make Phase 2 expansions easier, faster and cheaper. Instead of that, the length of the main breakwater has been designed with the appropriate length to avoid downtimes for berth operations.

Then, the proposed layout is the result of bringing together the environmental and physical conditions of the site with traffic expected by 2020.

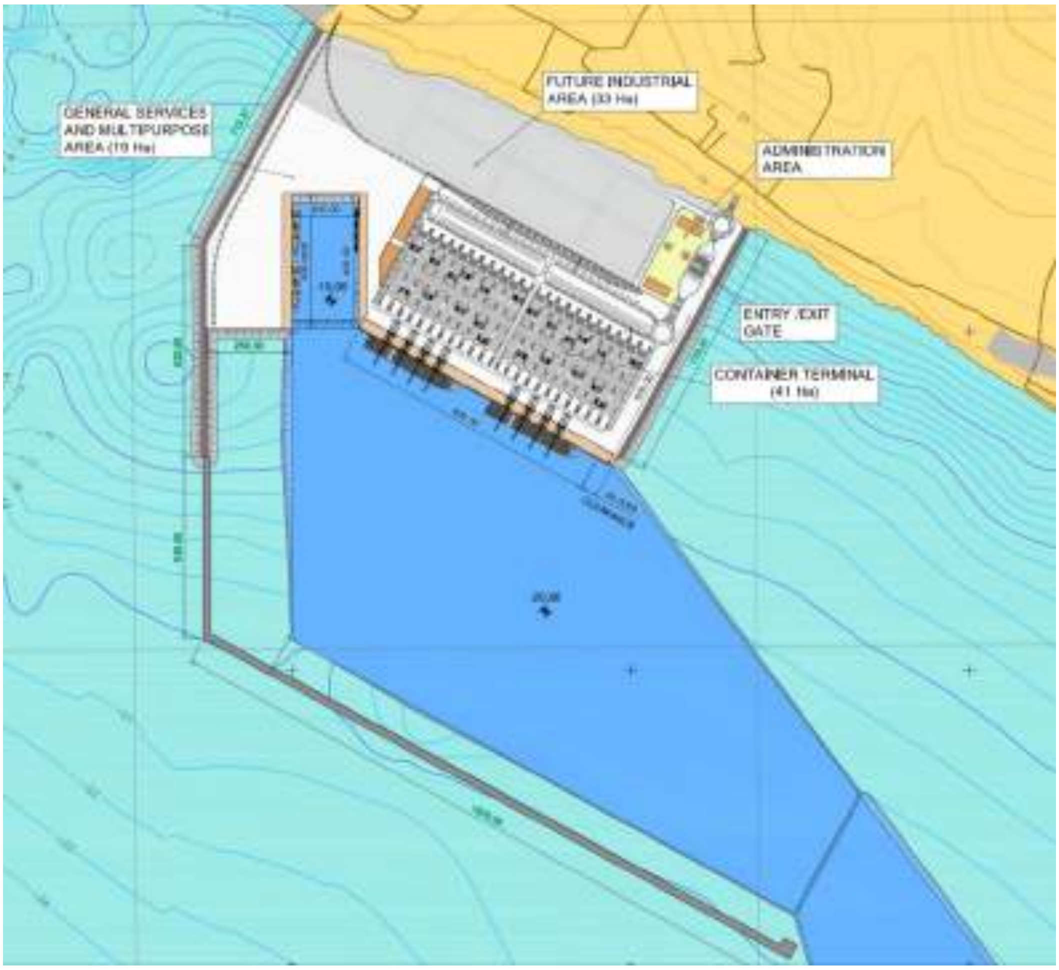


Figure 117: Port Layout for Phase 1

This layout is composed by the following main elements and figures:

Description	Units	Phase 1 (2018-2020)
Berths (total)	m	1,400
Container (2 berths)	m	800
General Cargo (1 berth)	m	400
Ancillary vessels (1 berth)	m	200
Terminals/Yards	Ha	93
Container	Ha	41
General services and multipurpose area	Ha	19
Industrial area	Ha	33
Breakwaters	m	4,630
Rubble mound	m	2,140
Vertical	m	2,490
Dredging and reclamation	Cu.m	10,123,273

Table 26: Main elements and figures of the port

The following chapters explain the criteria followed for planning of Phase 1 of the port's installations and its main characteristics. Also, the drawings included in Annexure 1 give more information about layout and details of the port.

9.2. BREAKWATERS

9.2.1. Introduction

Formulations to define the geometry of breakwaters have been obtained from the following codes, guidelines and manuals, among others:

- The Rock Manual (CIRIA)
- SPM (Shore Protection Manual, US)
- ROM (Recommendations for Maritime Works, Spain)
- PIANC Guidelines

The wave transformation from deep water to shallow water has been done for several points of interest near the breakwaters.

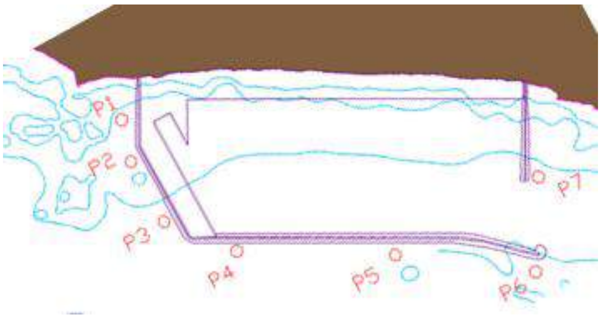


Figure 118: Location of points of interest

The result of this propagation is obtaining a wave height which has been taken as the first step for the preliminary design. So mean regime and extreme regime have been estimated in each point. All values are shown in the next table:

Shallow water Points	Mean Regime Hs (m)	Extreme Regime (200 years) Hs (m)
P1	1,78	4.00
P2	2,08	5.00
P3	2,00	4.80
P4	2,02	4.50
P5	2,02	5.00
P6	2,06	4.80
P7	1,99	4.90

Table 27: Wave heights in the points of interest

9.2.2. Rubble-Mound Breakwaters

This kind of breakwater is used in shallow waters, from the coast to a maximum depth of 15 m. Accropods for deeper sections and cubic blocks for nearshore sections, up to -6.0 m, have been considered for the armour units.

Hudson formula has been used for calculating the weight of armour unit:

$$W = \frac{\rho_r g H^3}{K_D \Delta^3 cot\alpha}$$

Where:

ρ_r=Mass density of Armour units

H=Design Wave Height

K_D=Stability Coefficient

$\Delta=(\frac{\rho_r}{\rho_w}-1)^3$

ρ_w=Mass density of Water

cot α=Armour Slope (H/V)

For randomly placed concrete armour units, Hudson formula has been rewritten by CIRIA as presented in the next equation:

$$(K_D cot\alpha)^{1/3} = \frac{H_s}{\Delta D_n}$$

Using the significant wave height, Hs(m) and the nominal diameter of the unit, Dn (m).

The value KD of the Stability Coefficient is KD=15 for accropods in the trunk of the breakwater portion and KD=6 for cubic blocks. Van der Meer formulas have been also considered for the design of the armour layer.

The main rubble-mound breakwater design is divided in three parts depending on the wave height. The east breakwater, which closes the container terminal, natural rock armour has been defined. Next paragraphs show each section main characteristics:

- First Section:

  It is the deepest part of the rubble-mound breakwater (around the depth of -15 m to -11m). The wave height has been taken from the point of interest P3 and P2, with Hs= 5 m. Accropods of 3 m^3 have been used for this section

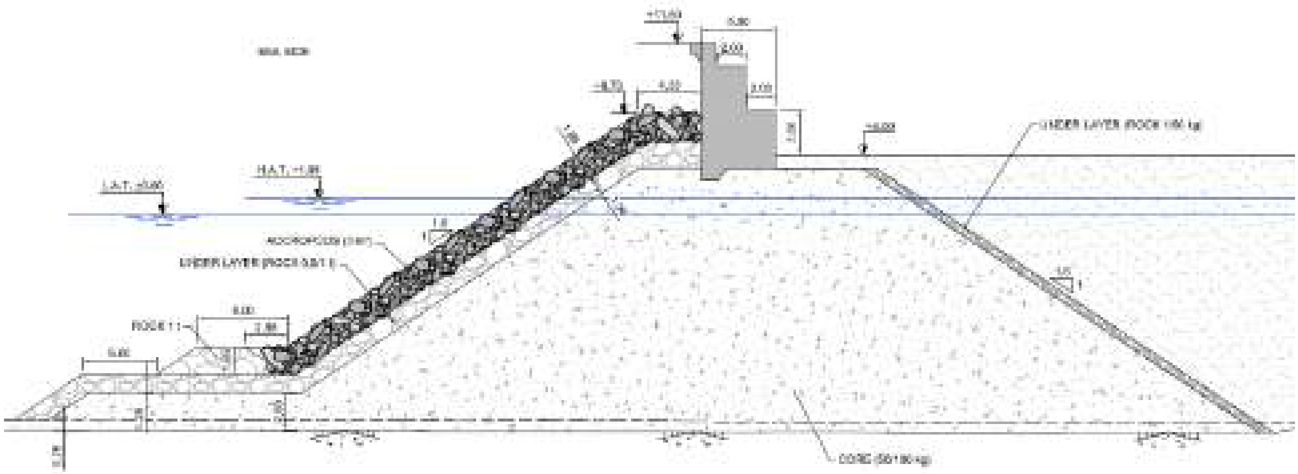


Figure 119: Rubble-mound section (3 m^3 accropods)

- Second section:

It runs between the depth from -11m to -6m, the wave height has been obtained from point of interest number 1 (P1) ,Hs=4 m . Accropods as armour units have been used, and the necessary volume has been 2 m^3.

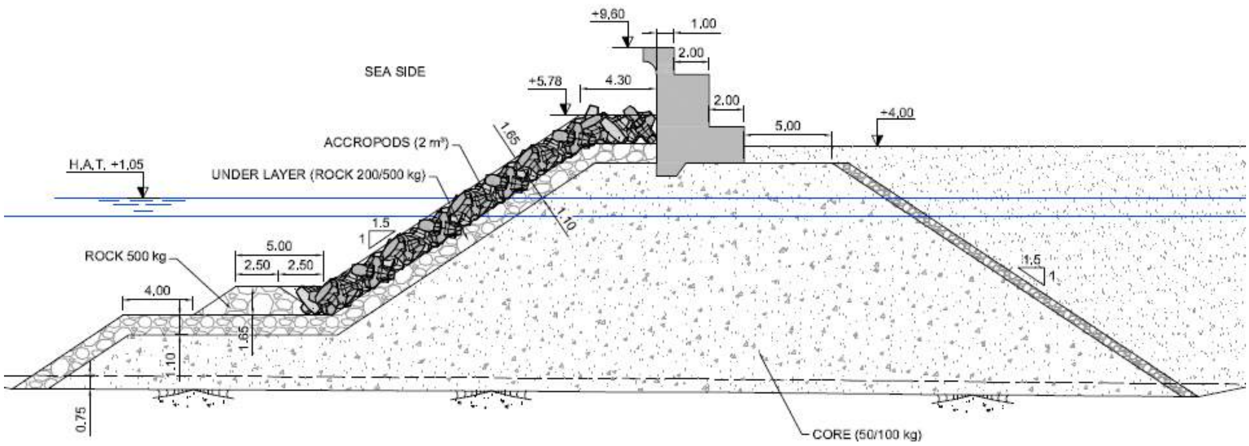


Figure 120: Rubble-mound section (2 m^3 accropods)

- Third section:

It runs between the -6 m contour line to the coastal line. Wave height has been obtained with an analytic method using different formulation for breaking wave:

The breaking wave depth is calculated with the Lineal Theory and Goda formulas:

$$\frac{H_b}{L_0} = 0.17\left(1 - \exp\left(\frac{-1.5\pi h_b}{L_0}\left(1 + 15\tan^{4/3}\beta\right)\right)\right)$$

The result is a wave height of 5 m, which breaks at the depth of -5.9 m

Once the wave height has broken, formulas from Dally et al (1985) have been used to calculate the wave height in different points near the coastal line:

$$\frac{H}{H_b} = \left[\left(\frac{h}{h_b}\right)^r (1+\alpha) - \alpha\left(\frac{h}{h_b}\right)^2\right]^{1/2}$$

$$\alpha = \frac{K\gamma_s^2}{\tan\beta\left(\frac{5}{2} - \frac{K}{\tan\beta}\right)}\left(\frac{h}{H}\right)_b^2 ;\ r = \frac{K}{\tan\beta} - \frac{1}{2}$$

The wave height is 3.3 m at the depth of -5 m. This has been taken for the rubble-mound breakwater design in the part near the coastal line using cubic blocks as armour units.

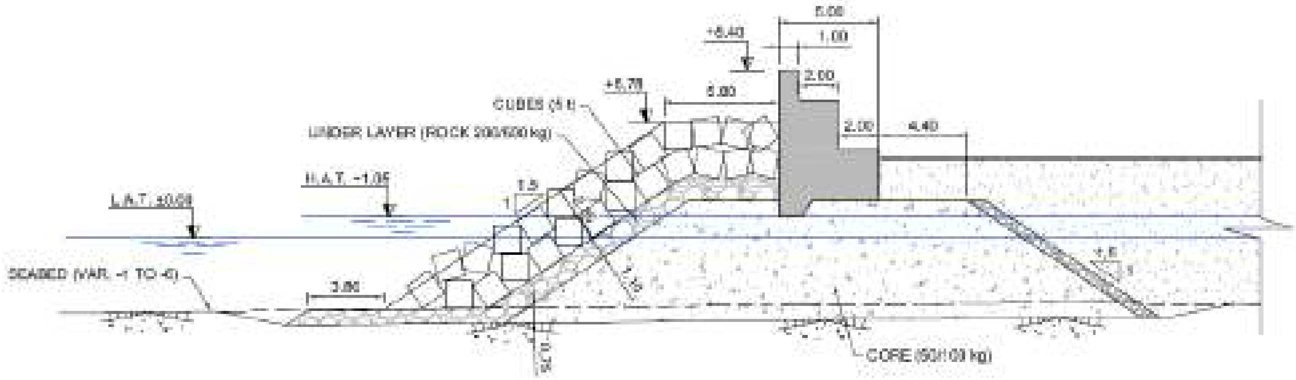


Figure 121: Rubble-mound section (cubic blocks)

- East breakwater:

  This structure closes the port on the east side of the container terminals. Calculations have been made following the same methodology as for the Third section of main breakwater. Given that this is a temporary breakwater until the works for next phase of the port begins, there is not a crown wall, but a rock protection on top of it. The typical cross section can be seen in the following figure.

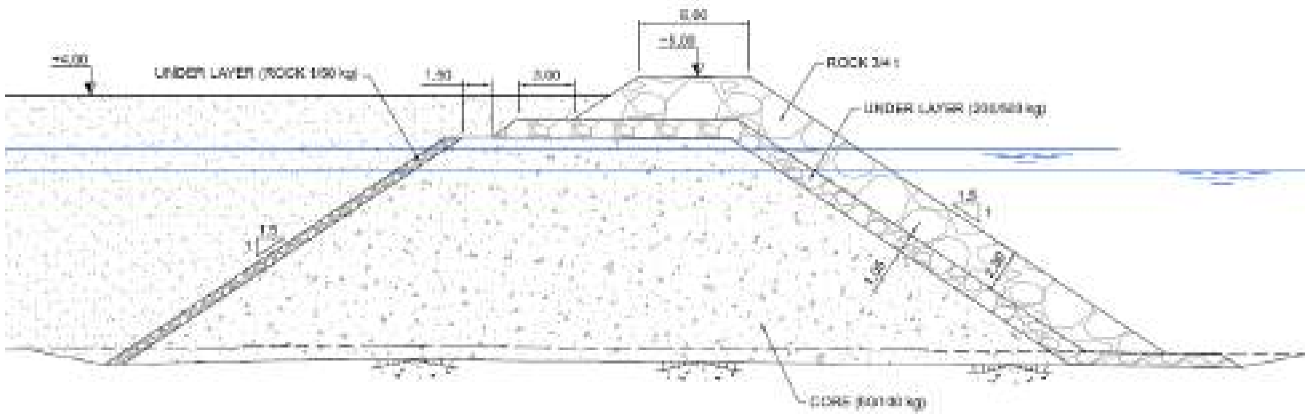


Figure 122: East breakwater section

9.2.3. Vertical breakwater

Vertical breakwaters have several advantages over rubble mound ones:

- Less quantity of material needed per meter of breakwater.
- The sheltered side of the breakwater can be used as a berth.
- Less time for construction due to the onshore manufacturing and the fast installation on site.
- Less environmental impact due to its lesser quantity of material and transportation.

This solution is widely used around the world. Many cases can be found in Japan (Mutsu-Ogarawa, Oga, Hoshiro…), Korea (Ulsan, Busan, Pohan…), Taiwan (Suao, Taipei…) or Qatar (Ras Laffan) in Asia; Italy (Genoa, Napoli…), Spain (Gijon, Algeciras, Valencia…), Greece (Piraeus) or France (Marseille) and Monaco in Europe, and Brazil (Porto de Açu) in South America.

Even for heavy sea conditions a vertical breakwater with floating concrete caissons can be used. For example, large caissons (52 x 32 x 34 m) have been designed and constructed in Gijon Port (Spain) for expected waves of 9.50 m of significant height and 19 seconds of peak period.

The following image shows the construction works of Gijon Port expansion, undertaken between 2005 and 2010.

Figure 123: Construction works of rubble mound and vertical breakwaters in Gijon Port (Spain)

This kind of breakwaters is calculated considering the wave forces, in compliance with all safety coefficients that are explained in several international codes (Spanish ROM 0.5-05 code has been used for preliminary design).

Different heights of crest have been considered depending on the possibility of overtopping. No overtopping is allowed for vertical sections which in Phase 2 and phase 3 will be filled in the port side. However, a small overtopping is allowed for the rest of vertical sections which will have only water in the port side.

9.2.3.1. Wave Pressure Formulas

The pressures which hit the vertical breakwater due to the dynamic wave action are obtained using Takahashi and Goda formulas. These pressures are shown in the pressures diagram below. These are the forces -together with the uplift pressures and the own weight of the structure- which determine the geometry of the vertical breakwater. The geometry of vertical breakwaters has to meet the safety coefficients as sliding safety coefficient (SSC) and roll-over safety coefficient (RSC).

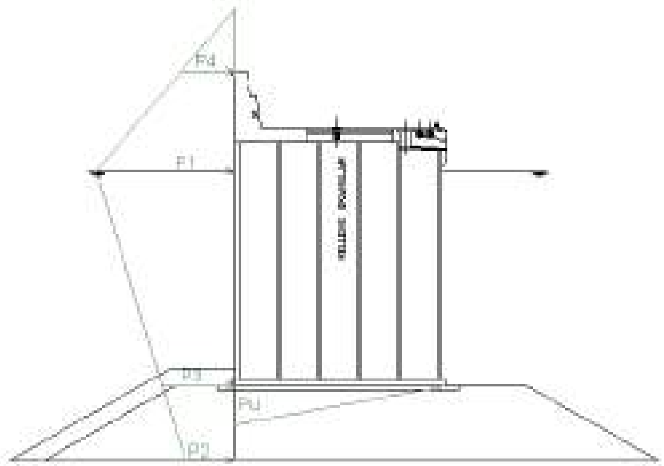


Figure 124: Pressure diagram.

9.2.3.2. Vertical Breakwater Section

The following figures show the vertical breakwater preliminary design:

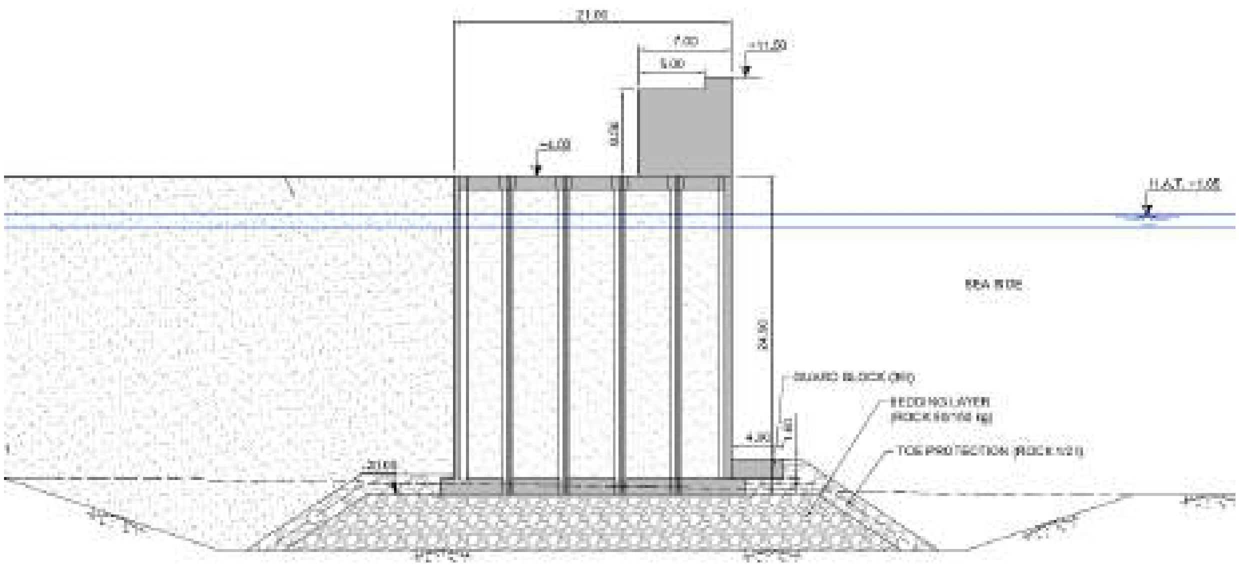


Figure 125: No overtopping vertical breakwater section

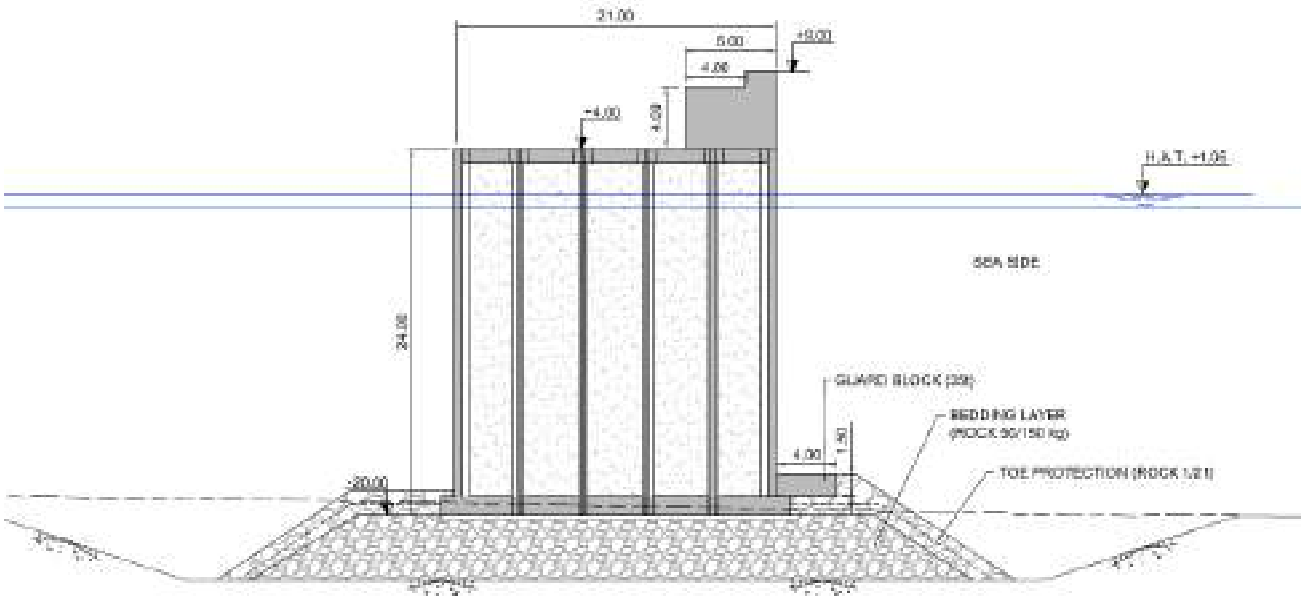


Figure 126: Vertical breakwater with an admissible overtopping

Further information of this study is enclosed in Annexure 5: Breakwaters Preliminary Design.

9.3. HARBOUR SHORT WAVE AGITATION

9.3.1. Introduction

The aim of the short wave agitation study, also called wave tranquility study, is to check that the proposed berths are well protected by the designed breakwaters. In order to check it, the downtime for the two berths is calculated through a numerical model which evaluates the tranquility for the proposed port.

The wave height inside the port must be limited to allow container vessels to not interrupt the operation of loading/unloading. Different international codes have been considered as IS 4651-V: Code of Practice for Planning and Design of Ports and Harbors, PIANC guidelines and ROM 3.1-99 (Spanish Recommendations for Maritime Work). Using the most strict criterion (ROM) the maximum operational wave height considered for container vessels is 0.5 m for waves forming an angle of +/- 45° over the fore and aft centerline of the vessel which is the case in this port.

9.3.2. Methodology

The methodology used is as follows:

- The Near shore wave climate has been analyzed in order to select the cases that have been propagated into the inner port with the agitation model.
- Six meshes have been defined for propagation. Depending on the peak period each case has been propagated in the appropriate mesh.
- Two areas have been selected for the proposed berths, and it has been also estimated the mean wave height in each area for each considered case.
- The downtime has been estimated for the proposed berths.

9.3.3. Selection of cases

The range of wave direction goes from South South-East (SSE) to the West (W), but the highest probability of occurrence is South South-West. The following criteria have been used to select the studied cases:

- Peak periods over 15s, because they are more energetic.
- The rest of cases below Tp=15s which have a probability of occurrence that can be relevant in the agitation study.

9.3.4. Areas of study

Two areas of study have been selected for the proposed berths depending on the mooring distribution for the vessels. The size of the areas has been defined taking into account the design vessel size. The next figure shows these areas:

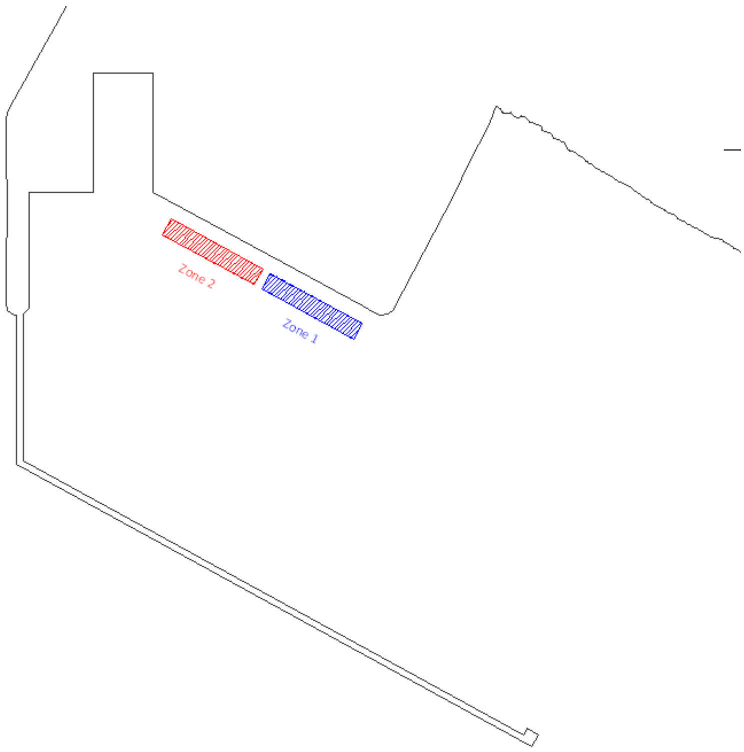


Figure 127: Areas of study (Berth line)

9.3.5. Downtime

Once the wave height has been calculated in each area for the cases under consideration, the next step is to estimate the downtime for the two proposed berths.

The table below shows the results of downtimes in days and hours for both options. These results show the inoperability of the different berths.

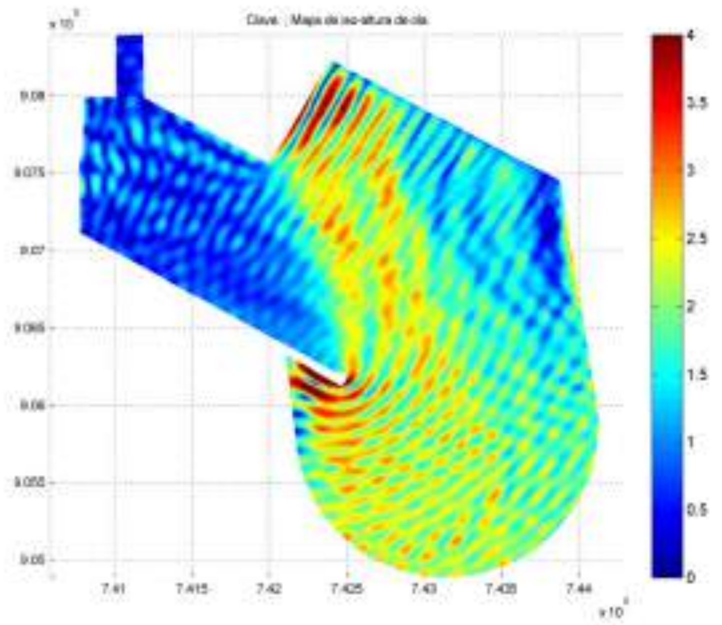
Description	Berth 1	Berth 2
Probability of occurrence (%)	0.49%	0.38%
Downtime (days)	1.57	1.40
Downtime (hours)	38	34

Table 28: Results of downtime in each berth

In conclusion, both berths have a very low downtime according to the recommendations for limit height by PIANC and ROM.

The following images give an insight of the wave agitation results for some relevant cases among all, which best shows the wave agitation inside the basin.

Hs	Tp	Direction	
2.00	14	SSE	157.5



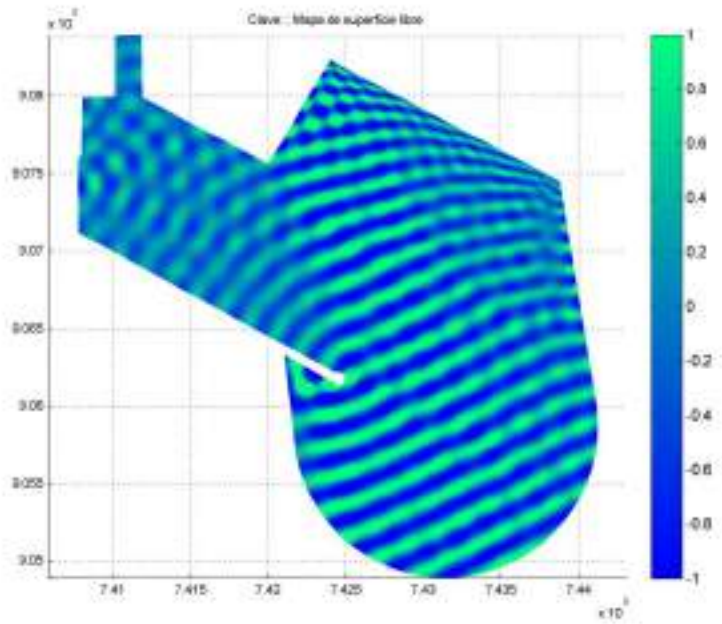
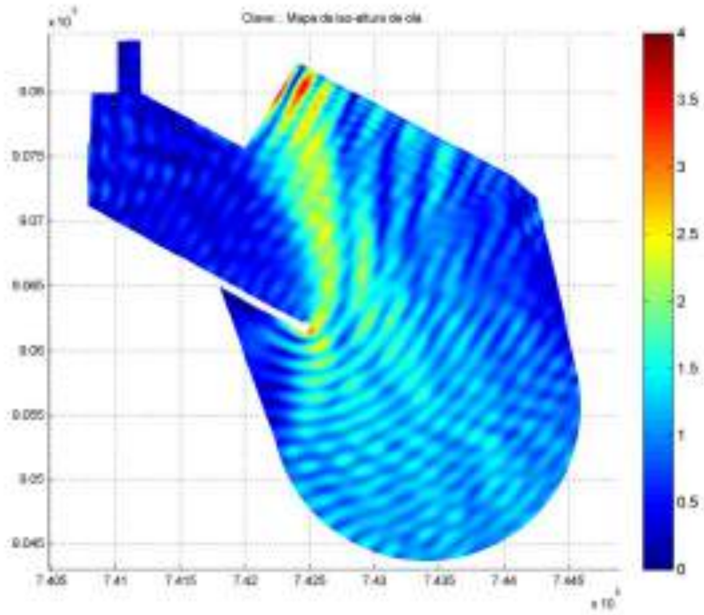


Figure 128: Option 1. wave height for Case 4

Hs	Tp	Direction	
1	18	SSE	157.5



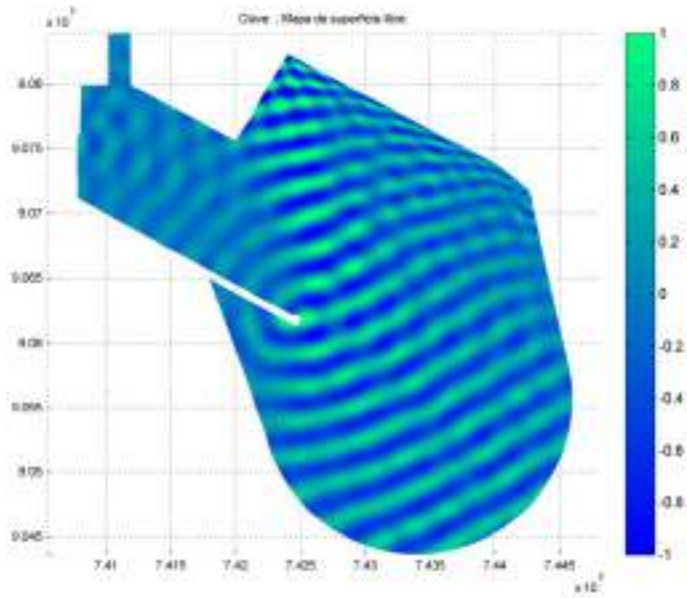


Figure 129: Option 1. Wave height for case 47

Further information of this study is enclosed in *Annexure 3: Harbour short wave agitation.*

9.4. NAVIGATION REQUIREMENTS

9.4.1. Vertical requirements

Both the outer channel and the inner channel (protected by breakwaters) must be designed to maintain a sufficient Under Keel Clearance (UKC) for the wind, waves and currents conditions for which a vessel can be moored and served on the berths. For this, ship related factors as ship squat, dynamic heel and wave response allowance, are the most important in vertical channel design.

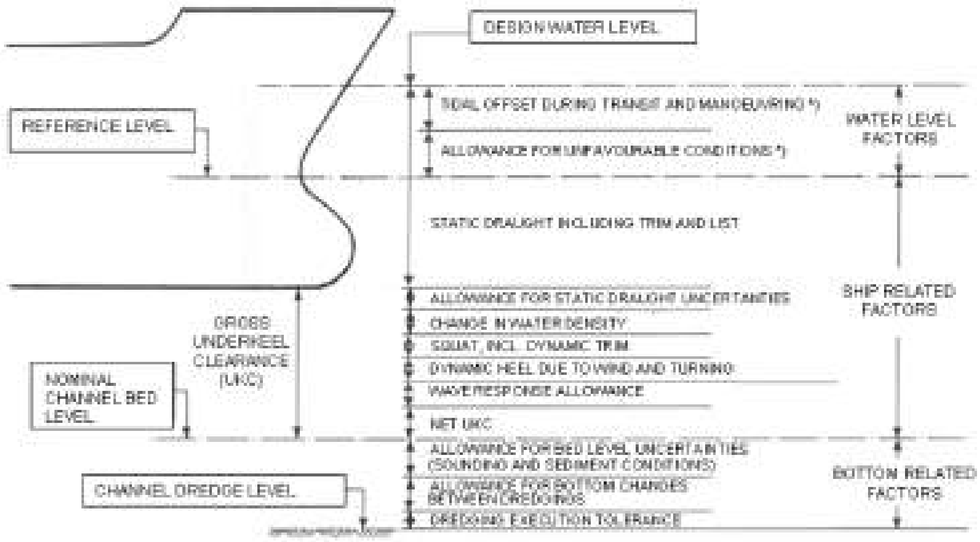


Figure 130: Channel depth factors (PIANC)

For concept design, the PIANC Report 121: *Harbour Approach Channels Design Guidelines* (2014) has been followed. In this document a ship related factor Fs which includes all of these ship effects is applied. This approximation depends on ship speed, intensity of wave effects on the design ship with its maximum draft T and type of channel.

For the design vessel (Maersk EEE type container vessel), with a 16 m draft (T) and 59 m wide (B), the results for inner and outer channel are as follows:

Factor	Inner Channel (m)	Outer Channel (m)
Ship Related factor (Fs)	17.92	20.80
Bottom tipe factor	0.40	0.50
Bilge keek factor (Sk)	0.70	0.70
TOTAL	19.02	22.00

Table 29: Channel depths for a 18.000 TEU container vessel.

The following components have been considered for calculations:

- Vessel speed: Moderate, 5-10 knots,
- Wave conditions: Heavy swell (Hs=2 m)
- Channel bottom type: Sandy

Although the needed depth for Phase 1 is 19.02 m inside the port (or less when more accurate studies and models are made), the need for reclamation material and the possibility of calls of larger ships in the future years such as larger container vessels or Capsize bulk carriers, lead to define a deeper dredging for approach channel (22.00 m) and basin (20.00 m).

Basin depth (under CD)	Outer Channel depth (under CD)
20.00 m	22.00 m

Table 30: Channel depths.

9.4.2. Horizontal requirements

In order to make a preliminary design of horizontal dimensions of water areas including orientation and alignment of the approach channel, the manoeuvring areas within breakwaters, turning circle, PIANC Report 121: *Harbour Approach Channels Design Guidelines* (2014) is applied. These dimensions are of great importance: first because they constitute a major part of the overall investment and second because they are difficult to modify once the port has been built.

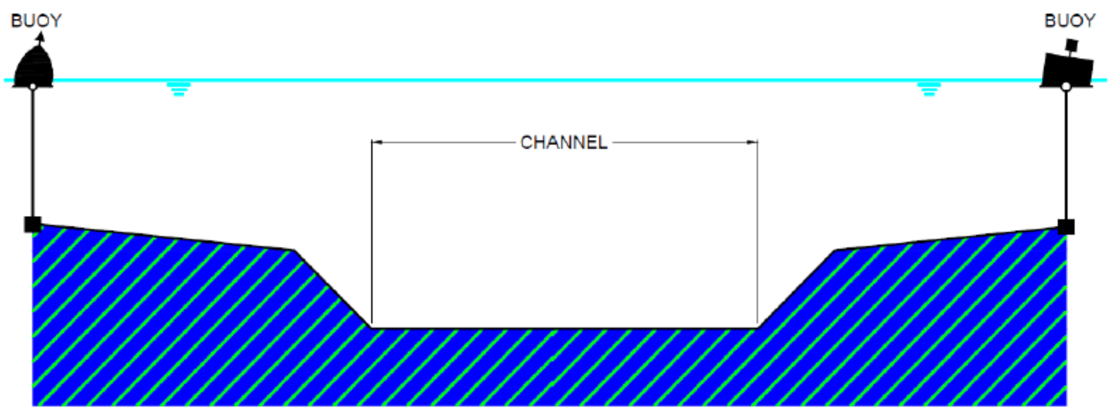


Figure 131: Basin and channel width definitions (PIANC)

The overall bottom width (W) of a straight channel is given by:

$$W = W_{BM} + \sum W_i + W_{BR} + W_{BG}$$

Where W_{BM} is the basic width, Wi is the additional width due to environmental actions, and W_{BR} and W_{BG} are the additional width due to side banks on each side of the channel.

For the case of Colachel-Enayam, those widths are shown in the table below:

Factor		Outer Channel (m)	Basin (m)
Basic Width (W_{BM})		88.50	88.50
Environmental (and other) Width (Wi)	Vessel speed	0.00	0.00
	Cross wind	23.60	23.60
	Cross current	41.30	35.40
	Long. Current	5.90	5.90
	Wave height	29.50	0.00
	Aids to navigation	11.80	11.80
	Bottom surface	5.90	5.90
	Depht of waterway	5.90	11.80
	Cargo hazards	0.00	0.00
Bank Clearance W_{BR}		59.00	59.00
Bank Clearance W_{BG}		5.90	5.90
Additional width in bends	Drift angle	12.00	12.00
	Response time	23.60	23.60
TOTAL		312.90	283.40

Table 31: Horizontal navigational requirements by factors

The entire basin will work as a turning circle, so there will be no inner approach channel properly.

Taking the former numbers as a minimum, and given the need of sand for reclamation, the preliminary dimensions for the channel are as follows:

Straight Outer Channel	Bend Outer Channel
400.00 m	>450.00 m

Table 32: Channel widths.

Regarding stopping distance and turning circle, PIANC states that stopping distance is $3 \cdot L_{oa} - 1 \cdot L_{oa}$ for tugs to go near the vessel and 2 L_{oa} for the actual stopping distance-, given the vessel enter the inner channel (or the basin) with an initial speed of 4 Knots.

The turning circle is the area where vessels are often assisted by tugs to their berths and may be turned beforehand. For a preliminary design, the nominal diameter for this circle is $2 \cdot L_{oa}$, which in this case is 2 x 400 m. Then:

Stopping distance (m)	Turning circle diameter (m)
1,200.00 m	800.00 m

Table 33. Stopping distance and turning circle diameter

This conceptual design for vertical and horizontal navigation requirements should be optimised or assessed in greater detail by using ship manoeuvring simulation in the next steps of the design process. These simulations can also be used to assess the requirements for manoeuvring in difficult situations, such as the usual south-west monsoon conditions, with heavy cross winds, heavy swell or a combination of both.

9.4.3. Aids to navigation

For this first approach to determine the navigational marks and aids, IALA (The International Association of Marine Aids to Navigation and Lighthouse Authorities) recommendations have been considered to design it. Also, opinions from navigational and Port Authority experts have been collected.

The following navigational marks have been defined:

- Starboard and port marks to be used in the entrance to the port.
- Special buoys set near south breakwater and south west breakwater to signal the area is not planned for dredging in Phase 1.
- Leading lights to indicate the navigation course.
- Cardinal marks to indicate depth limitation in approach channel.

Further information on navigational marks is included in Drawing-05.

Vessel Traffic Management System (VTMS) is also expected to be necessary for a proper operation of the port. This system should include at least a Radar, an Automated Identification System (AIS) base station, a VHF radio system, and a control station to integrate all components of the system.

9.5. DREDGING AND RECLAMATION

9.5.1. Introduction

In order to select suitable dredging equipment, it is necessary to take into account considerations about soil, dredging depth, environmental conditions, logistic factors, etc. This proposed methodology and equipment is prepared based on the information available at this stage but the final approach has to be developed by the contractors who are experienced and innovative in the field of marine dredging operation.

9.5.2. Dredging works

The total quantity of material to be dredged has been obtained by comparing the current bathymetry to the final geometry of the sea bottom as shown in Drawing-05: Dredging Plan:

DREDGING	
AREA (m^2)	QUANTITY (Cu.m)
2,739,862	6,819,280

Table 34. Dredging quantity and affected area

According to geological information available at this moment, the material to be dredged consists of loose to medium dense sand. All sand will be placed in the reclamation area. Considering dredging depth, environmental conditions and the amount of material to be dredged, the work method considers a Cutter Suction Dredger (CSD) in sheltered waters (inside port) and a Trailing Suction Hopper Dredger (TSHD) to carry out dredging of vertical breakwater trench (if needed) and approach channel. This combination of two equipments gives the dredging works enough flexibility to be finished in a short period of time, which is a requirement to commission the port before 2018 is finished.

Cutter Suction Dredger (CSD)

CSD is a stationary or self-propelled vessel that uses a rotating cutter head to loosen the material in the bed ('cutting'), which is extracted by a suction inlet located beneath the cutter head. CSD discharges the dredged material directly to shore via a floating pipeline or into a barge with a special loading system.

Figure 132: Cutter Suction Dredger

Main features of this kind of dredgers are listed below:

- Dredging depth up to 30 m
- Draught around 3 m, suitable to dredge an emerged terrain opening a channel.
- Suitable for dredging inner harbour (basin) and filling reclamation area.
- Wave height < 1m

- Discharging pipelines can be floating or submerged.
- Versatility related to dredging material: clay, loose materials and soft rock.
- Large number and variety of CSD are presented in the market.
- Dredging ratio in the range of 500-100,000 m^3/day

A medium-size CSD which can reach an average ratio of 20,000 m^3/day is suggested for this works, as it can fulfil the time requirements explained above.

Trailing Suction Hopper Dredger (TSHD)

TSHD is a self-propelled vessel that can dredge using suction tubes equipped with a drag head that is trailed over the ground. This vessel stores the dredging material inside the hopper.

Figure 133: Trailing Hopper Suction Dredger

Main features of this kind of dredgers are listed below:

- Dredging depth up to 100 m.
- Minimum draught around 5 m.
- Wave height < 3 m.
- Sailing speed around 2 knots while dredging, and up to 12 knots during transport.
- Hopper capacity in the range of 1,500 (small ones) and 38,000 m^3 (large ones).
- Discharging can be carried out by opening the hopper bottom doors, pumping the material by means of a pipeline, or throwing dredged material though a cannon (rainbow)

Figure 134: TSHD discharging by rainbow

Operation time required to discharge through the pipeline or cannon is about 1 hour. However, few minutes are required to discharge by means of opening the bottom. They are really efficient to dredge loose material and they have positioning and sailing advanced systems to guarantee the depth accuracy.

A small-size TSHD (2,000 m^3 of hopper capacity) is suggested to dredge both at the first stage of the works

9.5.3. Reclamation Works

Around 10.1 million cubic meters will be required for reclamation in Phase 1, broken down as shown in the following table:

ZONE	AREA (Ha)	QUANTITY (up to +2.00m) (Cu.m)
Container terminal	41.1	6,021,505
General services and multipurpose area	19.1	2,618,344
Entry/exit gate	3.5	220,337
Administration area	3.2	209,178
Future industrial area	30.8	2,562,986
Reclamation bunds	-	-1,509,077
TOTAL	97.7	10,123,273

Table 35. Breakdown of land reclamation quantities.

By contrast, a total dredging of around 6.8 million cubic meters will be required on Phase 1, so the rest of required material for reclamation (around 3.3 million cubic meters) must be obtained from other sources. It can be transported from quarries near Colachel, but the easiest and cheapest way to obtain that material is using the same dredging equipment and by dredging the basin of future Phases 2 and 3. This way dredging costs on Phase 2 and 3 is reduced.

The reclamation area will be filled up to +2.00 LAT. Then, a suitable capping layer and pavement will be used on top of the fill level around 2.00 m thick. Land-based equipment will be used to spread and level the delivered materials.

Bunds

In order to retain the dredging material in the reclamation area, bunds will be constructed around each of the reclamation areas prior to start filling.

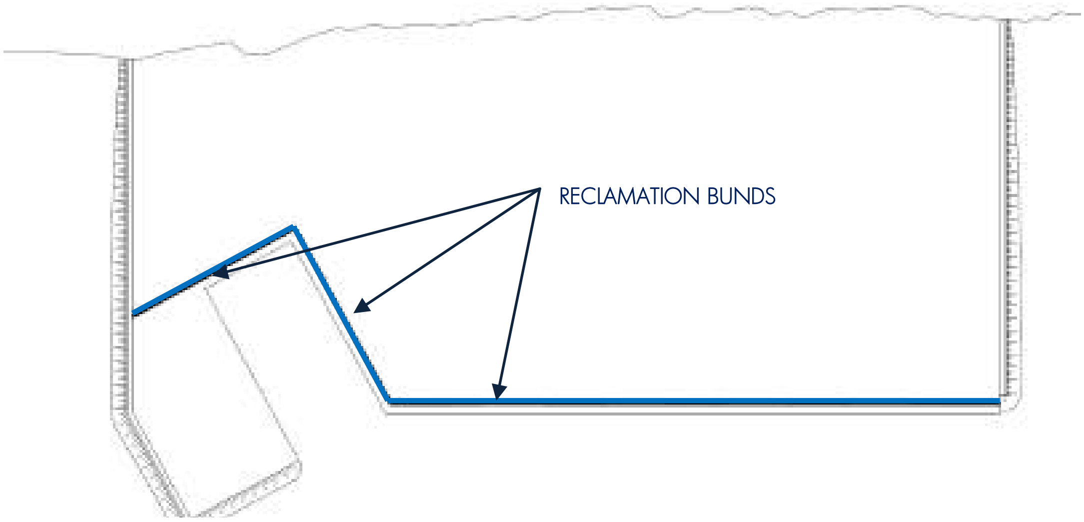


Figure 135: Proposed reclamation bunds

The proposed work sequence is the following:

- Rubble mound will start from the landside and will provide a permanent limit for the reclamation area at the west end.
- TSHD will be used to dredge the trench if necessary, in order to start construction of the vertical breakwater which will help to CSD to work in adverse weather conditions within the basin.
- Permanent reclamation bunds are to be constructed as shown in the figure, parallel to the berth alignment (west to east) and perpendicular to the shoreline at the east end.
- Dredging will be carried out at the basin and turning circle area, and material will be pumped to reclamation area.

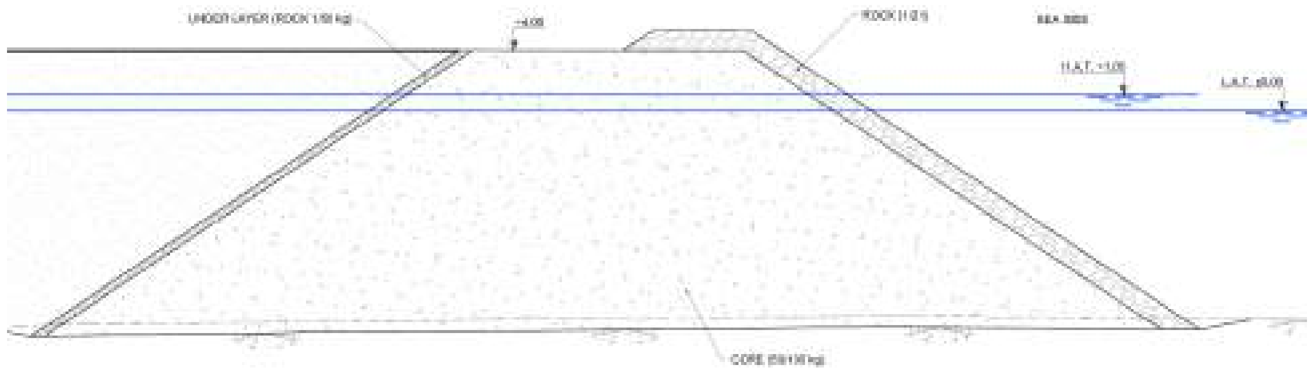


Figure 136: Cross section of reclamation bund

9.6. FACILITIES

9.6.1. Container terminal

A container terminal is an intermodal facility at which cargo is transferred from sea to land (both road and rail) and vice versa. It must be able to transfer cargo between the two quickly, efficiently and safely. It comprises three sub-systems:

- Dock: This is where merchandise is loaded onto or unloaded from the ship. It comprises the infrastructure of the dock itself and the equipment used to load and unload the containers.
- Container storage area: Every container has to pass through a storage facility before entering or leaving the port. There are various types and systems of storage depending on the layout of the containers, the equipment used or the degree of automation or the available spaces, among other aspects.
- Land entry and exit point: this comprises gates for trucks (which feature control and distribution elements) and for trains (with an area dedicated to train composition).

9.6.1.1. Handling system

In the case of this port, a semi-automated terminal is proposed, in which the container yard is laid out with stacks running perpendicular to the dock. This system allows for high storage capacity per square meter and high productivity, as it enables the movements of the dock to be independent of those of the yard itself.

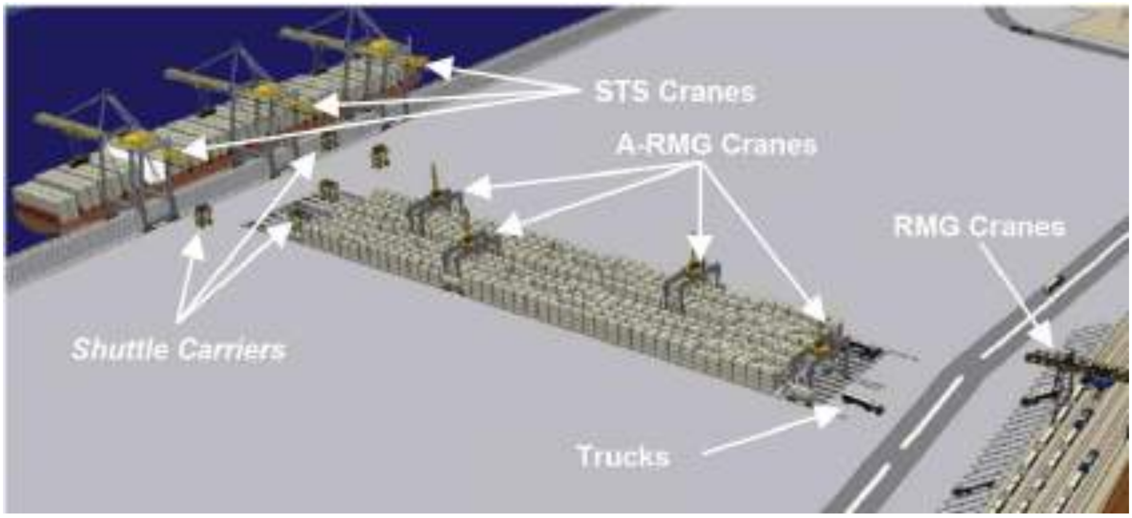


Figure 137: Scheme for container terminal operations

The main features of this kind of terminal are:

- Berth-yard transfer: Handling of containers between the quay cranes and the yard cranes is made by shuttle carriers (SC). The Ship-to-Shore cranes (STS) leave the container on the pavement and a shuttle carrier takes it to the water-side transfer area of the yard, or vice versa. Super Post Panamax cranes, with a minimum outreach of 65 m, must be used to attend 18,000 TEU vessels.

Figure 138: STS Crane (Liebherr)

The SC is a small straddle carrier whose only purpose is to transport containers from quay to yard and vice versa. Its main advantage is that it allows a complete separation of transport operations and loading/unloading of quay cranes and yard (decoupling). Thus, the STS cranes can unload containers directly on the floor independently of the presence of the SC, which can take or leave them independently of the cranes.

Figure 139: Shuttle carriers working

- Container yard. An Automated Rail-Mounted Gantry container crane (A-RMG) takes the container from the water-side transfer area and stocks it in the yard. Whenever is needed, the crane takes it and leave it on the land-side transfer area, where a truck is waiting to be loaded.

  This can occur to the other direction- a truck leaves the container and the ARMG stocks it in the yard and whenever is needed the crane leaves the container o the sea-side of the yard to be loaded into a ship. Usually, every block is covered by two ARMG, one for the sea side and the other for the land side.

Figure 140: Scheme and twin A-RMGs in an automated container yard

Apart from the automated yard, there are other stacking areas for empty containers or rail yard. Other equipment such as Reach Stackers (RS) or

Figure 141: Two different types of reach stackers (RS)

The connectivity from the yard to outside the container terminal can be done by two ways, by road or by railway. If the container enters or leaves the terminal by road, a normal truck is used.

On the other side, if the mode of transport is a train, a internal vehicle must transfer the container from the stacking yard to the rail yard. This can be made by reach stackers or internal vehicles like tractors. Loading the train car is usually made by Rail Mounted Gantry cranes (RMG), although it can be made by RS too.

Figure 142: Rail yard with Rail Mounted Gantry cranes

A total of 9 STS cranes, 44 A-RMG cranes, 16 SC, 2 RMG cranes for the rail yard, 2 RS and 4 tractors have been estimated to be needed for terminal operations.

9.6.1.2. Berths

Berths must be sized to cater the estimated handlings over it. With this aim, some parameters must be also estimated and calculated:

- Mean Vessel Size: Size of the mean vessel obtained from the studies carried out analyzing similar ports near Colachel.
- Container moves per vessel. Market data and container terminal studies give the usual percentage of moves over the total capacity of the vessel is between 30 and 50%. It is expected that this percentage will be growing from 2018 to 2030. For capacity calculations, 1750 movements per vessel call are used.
- Cranes per vessel. 9 cranes are planned for two berths. This means each berth will have 4.5 cranes.
- Handlings per crane. Usually this variable goes from 25 to 35. Since this port must be competitive to others like Colombo, 30 moves have been estimated for capacity calculation. This productivity could grow over time as crane operators improve their skills.
- Peak berth utilization: 70% is used for berth capacity calculations. While 60 % is a usual factor for normal operation, a terminal is able to afford up to 70% with some congestion. This congestion will only occur when the terminal is reaching its maximum capacity and will be expanded soon.
- Operational Time: Three shifts of eight hours each with one hour break can be expected. 21 hours a day, 7 days a week, 52 weeks a year is use for capacity analysis.
- Unproductive Time at Berth: A mean value of 3 hours per vessel call is assumed.
- Peak/mean week occupation ratio: Peak week demand of the terminal is usually 10% higher than the average, so 1.1 is the ratio used for calculations.

These parameters lead to a total capacity of 2,016 TEUs per meter of berth and per year. This is in line with the latest recommendations for designing container terminals in India. The terminal total capacity is close to 1.7 M TEUs forecasted in the traffic study.

The following table summarizes the capacity calculations:

Description	Unit	Value
Berth capacity		
Handling/TEU ratio		1.5
Mean vessel size	TEU	6,540
Container handlings per vessel (35%)	No	1,750
Container handlings per crane	No	30
Unproductive time at berth per vessel	hr	3
Mean number of cranes per vessel	No	4.5
Crane work hours per day	hr/day	21
Peak berth utilization	%	70
Peak/mean season occupation ratio		1.1
Total capacity per berth	TEU/yr	803,295
Number of berths		2
Terminal capacity	TEU/yr	1,604,208
Capacity per linear meter of berth	TEU/m/yr	2,005

Table 36: Berth capacity calculations

9.6.1.3. Container yard

The capacity of a container yard is governed by the following parameters:

- Mean Dwell Time: Time a container stays inside in the yard. 4.5 days for loaded containers (a mean value of 3 for trans-shipped and 6 for gateway) and 8 days for empty ones is used for calculations. These numbers are usual in other container terminals around the world.
- Slots: This is the total number of twenty - foot ground slots of the container yard. The planned terminal is composed by:
  - 5,112 loaded container slots
  - 432 reefer container slots
  - 600 empty container slots
- Mean Storage Height: In an automated yard this height can be around 75 % of the maximum storage height -5 for normal containers, 4 for reefers and 7 for empty containers. 70 % is used taking into account some other factors like peaks and re-organization activities.

The total capacity of the container yard is almost 1.8 M TEU. Given the variability of the dwell time, this allowance from the 1.7 M TEU traffic forecasts seems appropriate.

The following table summarizes the capacity calculations:

Description	Unit	Value
Yard Capacity for loaded containers		
Slots (9 lines, 30 rows blocks)	No	5,544
Mean dwell time	days	4.5
Maximum storage height	No	5.00
Mean storage height (70%)	No	3.5
Total Capacity for loaded containers	No/yr	1,573,880
Yard Capacity for empty containers		
Slots (20 feet)	No	600
Dwell time	days	8
Maximum storage height	No	7
Mean storage height	No	4
Total Capacity for loaded containers	No/yr	109,500
Total slots	No	9,316
Mean dwell time (loaded+empty)	days	4.9
Mean storage height (loaded+empty)	No	3.6
Total Yard Capacity	No/yr	1,790,143

Table 37: Yard capacity calculations

9.6.1.4. Gates

Gates are the exit and entry point for all truck traffic. It is expected that 75-80% of total gateway traffic will be by truck -and the other 20-25% will be by train. These shares lead to around 0.53 million trucks for 2020.

Based on other projects developed by TYPSA-BCG, an initial estimation of 9 reversible lines -plus 2 more lines for other traffic as maintenance, staff, rejected trucks, etc.- has been made. Further calculations in next stages of the design for capacity assessment should be performed to better assess the capacity of the gates. These calculations should take into account parameters like working hours, type of gates and pre-gates, and peak factors.

9.6.1.5. Rail yard

The rail yard will handle all containers entering or exiting by train. As explained above, around 20-25% of gateway traffic will be by train. These shares lead to around 0.17 million containers for 2020.

An initial estimation of 4 spurs -plus other 2 lanes for manoeuvres and connection to next phases of the port- and three RMG cranes have been provided.

In order to assess accurately the capacity of the yard, the necessary calculations in next stages of the design should be performed, taking into account parameters like working hours, crane performance or dwell time, and peak factors.

9.6.2. Multipurpose and ancillary berths and terminals

Although there is no forecast for general cargo, a 400 m general cargo and multipurpose berth is included in the port layout. This berth will allow the container terminal to be very specialized and avoid interruptions in operations. Cruisers are also able to berth in this terminal.

Besides, a 200 m berth for ancillary vessels such as tugs, pilots and mooring launches is included in the facilities.

9.6.3. Solid bulk terminal

Coal traffic is expected to begin in 2022. A solid bulk terminal is included in Phase 2 development to cater this cargo.

This terminal consists of a 400 m long and 20 m deep berth. To assess the berth capacity, the following table shows the parameters and values taken into consideration:

Description	Units	Value
Quay crane productivity	T/hr	2,000
Annual working days	Days/yr	365
Daily working hours (3 shifts)	h/day	21
Berth capacity (occupation)	%	75
Yard Capacity for loaded containers	T/yr	11,497,500

Table 38: Coal berth performance assumptions.

This calculation means the berth could cater all coal traffic with only one crane, although having only one might cause difficulties to serve ships in case of malfunction.

The stockyard is equipped with conveyors and stackers/reclaimers, standard equipment for this kind of terminals.

Figure 143: Some examples of coal terminal equipment. Gantry crane (left) and stacker/reclaimer (right)

The following figure shows the layout of the terminal on Phase 2, whit a total area of 9 Ha, while in Phase 3 the terminal will be duplicated to 18 Ha to be able to cater the expected coal traffic.

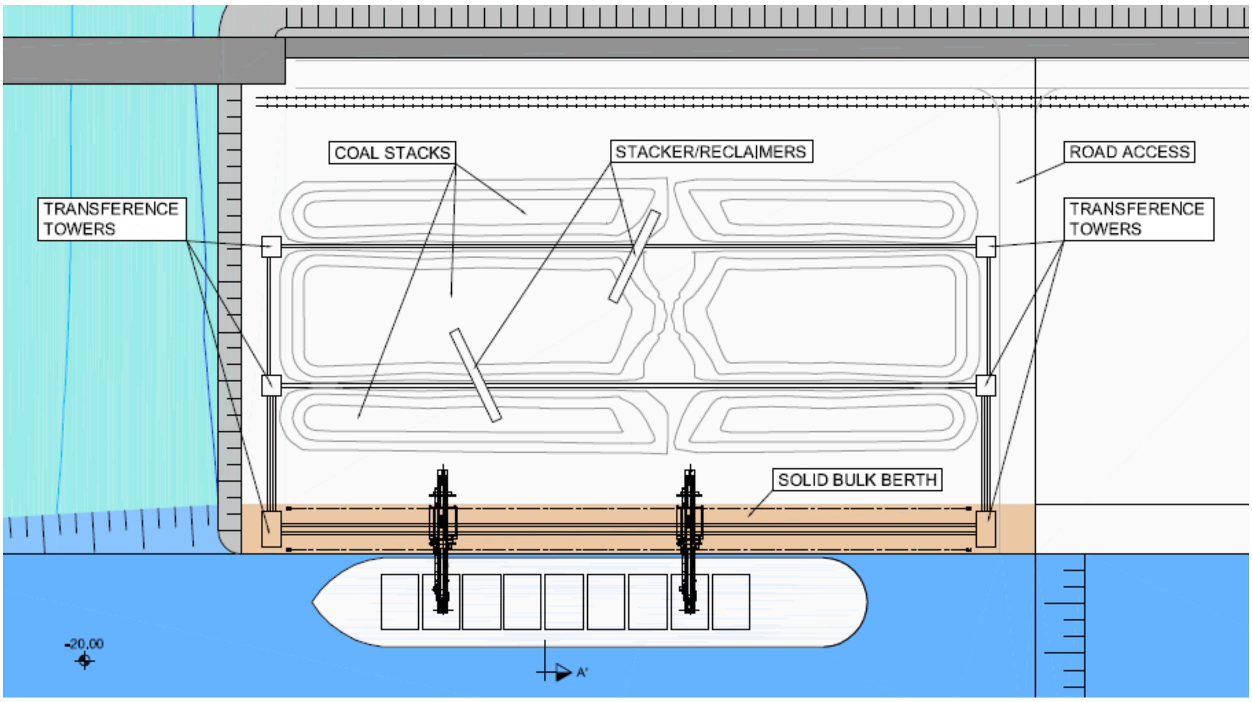


Figure 144: Coal terminal layout on Phase 2

9.6.4. Buildings

Some administration and control buildings will be required for the new port. The following list includes the most important ones –which have been foot printed on the drawings:

- Port administration building

- Police station
- Fire station
- Customs

The container terminal includes:

- Maintenance workshop
- Marine operations building
- Administration building
- Entry/Exit gates

Some other buildings might be added in future stages of the design process.

9.7. PORT PLANNING FOR PHASES 2, 3 AND FUTURE EXTENSION

When traffic is near Phase 1 capacity, Phase 2 expansion must be developed to service the new traffic.

Phase 2, planned from 2021 to 2025, consists of a 2,000 m extension of the container berth and another 92 Ha for container terminals, and a new 400 m berth and 9 Ha for a new coal terminal on the west side of the port.

Container terminal capacity in this phase is around 5.6 million TEUs per year and more than 10 M tonnes of solid bulk (coal).

Phase 3, planned from 2026 to 2030 consist on extending the container terminal by 1,200 m of berth and 95 Ha of yard. This will mean 4,000 m of total berth line which gives a total capacity of 8 million TEUs per year. Regarding solid bulk terminal, it will be duplicated to a total berth of 800 m and a total stockyard of 18 Ha.

Both the Phase 2 and Phase 3 coal berths have been planned to be built with the possibility to be converted into a container berth in case of the container traffic raises beyond expected rates and coal traffic below expected.

The following table shows the main figures and characteristics for the three analyzed phases of the port (cumulative figures):

Description	Units	Phase 1 (2018-2020)	Phase 2 (2021-2025)	Phase 3 (2026-2030)
Container Terminal Capacity	TEU	1,606,590	5,623,064	8,032,949
Bulk Capacity (coal)	M. Ton	0.00	3.30	6.60
Berths (total)	**m**	**1,400**	**3,800**	**5,400**
Container	m	800	2,800	4,000
Multipurpose	m	400	400	400

Ancillary vessels	m	200	200	200
Solid bulk	m	0	400	800
Terminals/Yards/Areas	**Ha**	**93**	**249**	**379**
Container	Ha	41	133	228
General services & multi- purpose	Ha	19	19	19
Solid bulk terminal	Ha	0	9	20
Industrial area	Ha	33	88	112
Breakwaters	**m**	**4,639**	**7,237**	**8,904**
Rubble mound	m	2,133	2,842	3,402
Vertical	m	2,506	4,395	5,502
Dredging and reclamation				
Dredging	Cu.m	6,819,280	13,151,903	14,973,161
Reclamation	Cu.m	3,303,993	12,866,152	19,261,679

Table 39: Main figures for Phase 1, 2 and 3 (cumulative figures)

A future extension beyond Phase 3 is possible in order to increase the port capacity to 16 million TEU. This extension can be made converting the vertical breakwater into a berth line and a new landfill area shall be developed seawards.

Figure 145: Layout for future extension of the port

Further information regarding Phase 2, 3 and future extension (Phase 4) are included in Drawing-02, Sheets 1 to 4.

10. CONNECTIVITY PLANNING

10.1. INTRODUCTION

As stated in chapter on Key imperatives, transport linkages with the port hinterland are a key factor for the success of the project. One million TEUs are expected to travel from or to the port hinterland, and suitable connections by road and rail must be developed to facilitate this traffic.

Next sections show a first approach of these linkages to assess their feasibility, preliminary calculation of costs, land requirements and to allow an initial environmental and social impact evaluation. Further studies should be developed to optimize this preliminary design in order to reduce the impact on housing and properties. These studies are explained in section 15 of this report.

10.2. RAIL CONNECTIVITY

A 20 or 25% of the gateway traffic is expected to travel by train. That means around 0.25 Million TEU or 3.85 million tonnes in 2020.

A single lane broad gauge track runs parallel to the west coast of India. Several alternative layouts of a new railway which connects to the existing one have been analyzed to know which is better in terms of environmental impact, length, slopes, and earthworks.

All alternatives have been chosen according to the following criteria:

- Avoid densely populated areas.
- Limit the maximum slope to 0.12 %.
- Limit the minimum radius to 500 m, apart from connections on the existing railway and the port.

The most suitable two of them are shown in the figure 146.

Figure 146: Alternatives 1 (green) and 2 (black) for rail connectivity

A double broad gauge track has been considered for linking the port and the main track. The typical cross section is:

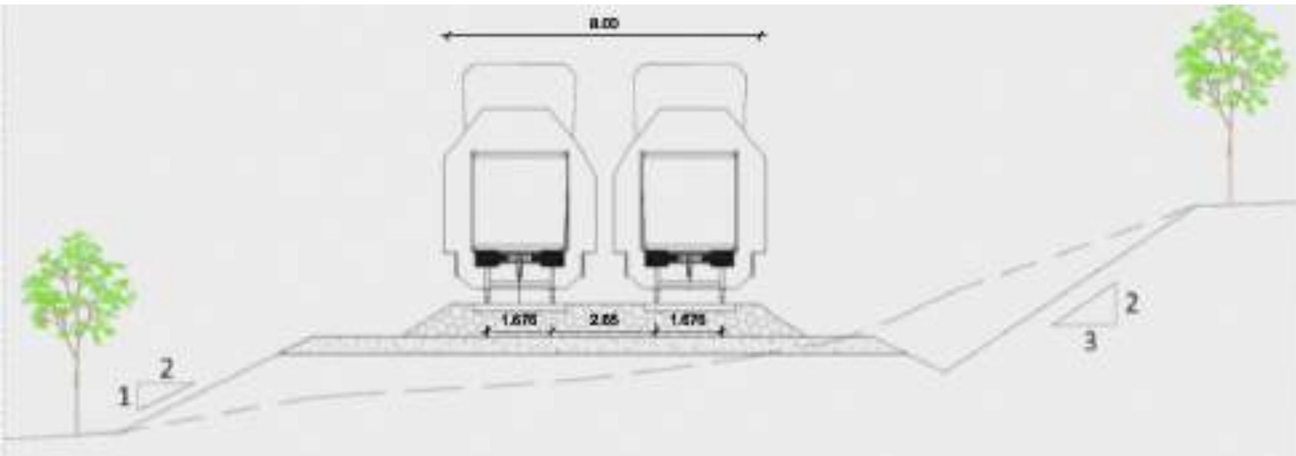


Figure 147: Connecting railway typical cross section

The shortest and less costly option in terms of earthworks is alternative 1 (green). Its main figures are shown in the following table:

Description	Unit	Value
Minimum radius	m	500
Maximum longitudinal slope	%	1.20
Length	m	9,985
Cutting volume (at a 3H/2V slope)	Cum	756,500
Filling volume (at a 2H/1V slope)	Cum	348,000

Table 40: Main figures of the rail connection.

A plan view and a longitudinal profile are included in the set of drawings.

10.3. ROAD CONNECTIVITY

A 75-80 % of the gateway traffic is expected to travel by road. That means around 0.80 Million TEU and around 0.53 million trucks –in addition to the cars- travelling to and from the port can be expected in 2020.

In the same way as the rail linkage, several alternative layouts of the four lane connecting road have been analyzed.

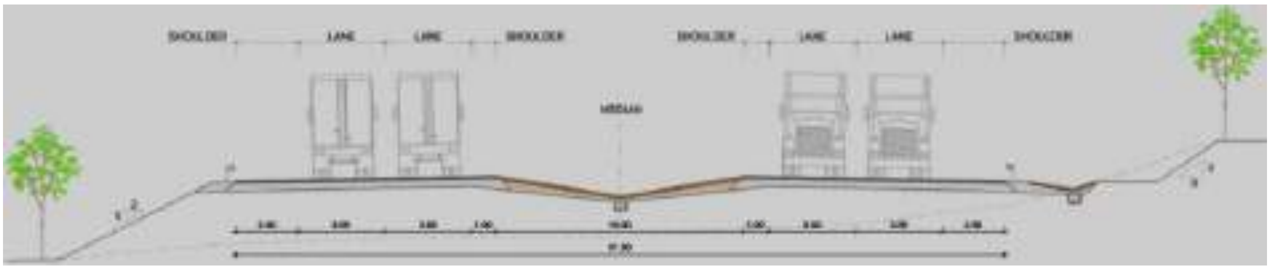


Figure 148: Connecting road typical cross section

The applied criteria for these layouts are as follows:

- Avoid densely populated areas.
- Use (as far as possible) the existing roads.
- Limit the maximum slope to 4 %.
- Limit the minimum radius to 300 m.

The most suitable two of them are shown in the figure.

Figure 149: Alternatives 1 (blue) and 2 (red) for road connectivity

The shortest and less costly option in terms of earthworks is alternative 1 (red). The main figures are shown in the following table:

Description	Unit	Value
Minimum radius	m	300
Maximum longitudinal slope	%	4.00
Length	m	11,806
Cutting volume (at a 3H/2V slope)	Cum	1,135,000
Filling volume (at a 2H/1V slope)	Cum	831,000

Table 41: Main figures of the road.

Also, a plan view and a longitudinal profile are included in the set of drawings.

NHAI is currently undertaking a project to expand NH 47. The project is under NHDP-Phase-III and includes four laning of NH 47 from Villukuri to Kanyakumari and four laning of NH 47B from Nagercoil to Kavalkinaru. Currently land acquisition for the project is ongoing. The stretch of NH 47 & NH 47 B from Villukuri to Nagercoil to

Kavalkinaru is expected to be the principal evacuation route for the Colachel port. This stretch would connect NH 47 to NH 7 which then would further connect to the key hinterland areas of the port. This stretch is expected to handle approximately ~1 Mn trailers annually (import, export and empty trailers) by 2025 for the Colachel port. To ensure that the road has the capacity to handle the trailer volumes generated by the container traffic in the Colachel port without congestion, the planned road from Villukuri to Nagercoil to Kavalkinaru can be developed as a six lane road under the current road expansion project. This project can further cover the extension of the six lane road till the location of the Enayam port. Requisite land acquisition can be commenced along with the current land acquisition for the broadening of NH 47.

10.4. IMPLICATIONS ON LAND RECLAMATION

These linkages run almost perpendicular to the shore, within the Vilavancode Taluk of Kanyakumari District and, as is shown in the annexed drawing, they cross several villages of that taluk.

Specifically, the following villages will be affected:

- Karungal (TP) Midalam
- Keezhkulam
- Paloor
- Kylliyoor
- Nattalam

The table shows the initial rough estimates of the impacts of land acquisition for the railway and road links at each of the affected villages, as shown in Drawing No 7, sheet 2 of 2. The areas have been calculated assuming a 60 m wide corridor for road and a 40 m wide corridor for railway, as stated in previous sections.

VILLAGES	ROAD LINKAGE		RAILWAY LINKAGE	
	Length (m)	Area (Sq.m)	Length (m)	Area (Sq.m)
Karungal (TP) Midalam	390	23,400	-	-
Keezhkulam	2,765	165,900	3,813	152,500
Paloor	3,084	185,000	3,136	125,400
Kylliyoor	1,711	102,700	795	31,800
Nattalam	3,843	230,600	2,242	89,700
TOTAL	11,793	707,600	9,986	399,400

Table 42: Rough impact estimates on land acquisition.

The boundaries used to calculate affected distances and areas of each village have been taken from the Coastal Zone Management Plan (CZMP) of Tamil Nadu, developed by Department of Environment of the Government of Tamil Nadu. In turn, the CZMP has used the Cadastral Map of scale 1:5000, and other complementary sources.

As stated before, the layout and, in turn, the affected villages, lengths and areas can be modified in latter phases of the project, when the design will be optimized.

11. INITIAL ENVIRONMENTAL EXAMINATION

The Initial Environmental Examination (IEE) Report (included as Annexure 5) deals with the Environmental issues related to the Project in order to assess the likely impact. The IEE has been conducted within the short time available. The study mainly depends on secondary data on physiological condition of the area. Some field verifications have been undertaken by the study team for updating the secondary data when it was necessary.

IEE has been carried out as part of this TEFR, in order to determine whether the Project will be environmentally feasible. The general objectives of IEE study have covered the following:

- *To provide information about the general environmental settings of the project area as baseline data.*
- *To provide information on potential impacts of the project and the characteristic of the impacts, magnitude, distribution and their duration.*
- *To provide information on potential mitigation measures to minimize the impact including mitigation costs.*
- *To provide basic information for formulating management and monitoring plan.*

The indicative outline of the IEE report is as follows:

- A. Introduction.
- B. Description of the Project.
- C. Description of the Environment.
- D. Screening of Potential Environmental Impacts and Mitigation Measures.
- E. Institutional Requirements and Environmental Management Plan.
- F Conclusions.

The development of proposed Colachel Port at Tamil Nadu offers an efficient and cost effective supply chain/value proposition to the local importers and exporters. This could trigger a new set of opportunities as induced developments.

11.1. ALTERNATIVE ASSESSMENT

Initially, 4 alternatives were considered for the location of the port infrastructure. After a multicriteria analysis where the environmental and social factors played a key role together with the rest of the project components Enayam, was considered as the best rated alternative location, with the lowest impact, while the worst rated one, with the highest impact, was Colachel. Kanyakumari and Manavalakurichi obtained similar intermediate ratings.

The Enayam location has lower environmental impacts than the others with respect to dredging, cultural sites and its low impact on property due to its low population. Port expansion will not need a wide extra inland area since the land reclamation area will provide room for port facilities and industries.

11.2. PROJECT BENEFITS AND LAND ISSUES

Dedicated roadway and railway connectivity proposed for the Colachel-Enayam port would provide access to the major existing road and railway network which offers an efficient and cost effective supply chain/value proposition to the local importers and exporters in the State of Tamil Nadu. Employment opportunities to the local people would rise for skilled, semi-skilled and unskilled work force during the construction and operation phases

This will accomplish one of the main objectives of the proposed port project, bringing significant benefits to local people and to the region as a whole and positive impact on the socioeconomic conditions of the project region and the whole Tamil Nadu State.

However, the activities during the construction phase might have some other potential impacts on the socio-economic environment which includes dredging, reclamation, transportation of quarrying materials, construction of terminals and breakwater as well as establishment of labour camps. During the operation phase, the operation of terminals, marine traffic, road & rail traffic and establishment of labour/employee colony might have potential impact on the socio-economic environment of that region. However, as the port is planned to be developed entirely on the reclaimed land, no land acquisition is envisaged for the port development.

However, a total number of 427 properties would be directly affected by the implementation of the railway line and road connections. Apart from that, being an international harbour, the port would require additional basic infrastructure facilities, administrative buildings cruise and navy operations facilities, warehouses, residential areas, truck parking areas. Hence, backup areas in the immediate vicinity will be required in the future for developing other further facilities.

11.3. ENVIRONMENTAL IMPACTS, MITIGATION MEASURES AND EMP

As for the impact onto the current environmental conditions, the port activities and their impacts on the environmental and social attributes during the development and operation phase have been discussed in detail.

It was concluded that most of the negative effects that may take place with the implementation of the project could be mitigated with the adoption of appropriate mitigation measures, both in construction and operational phase and the effective implementation of the proposed environmental management and monitoring programmes.

11.4. PRELIMINARY BUDGET FOR ENVIRONMENTAL AND CSR MEASURES

A preliminary environmental budget plan to address all environmental management requirements has been prepared. Some of the key areas identified are the following:

- Environmental (terrestrial and marine) monitoring in both construction and operation phase: monitoring of Shoreline changes in Colachel-Enayam coast in both construction and operation phase
- Water & wastewater management; Solid waste management
- Groundwater development at Project Area:; Focused water supply augmentation study in the 5 km study area; Storm water management and rainwater harvesting is also planned
- Employment for solid waste management using Women Self Help Groups (SHG)
- Fishermen who lost livelihood opportunities will be given preference in providing employment, scavenger boat operations. STP operators for the streams will be from those groups who lost livelihood opportunities
- Rainwater harvesting, desiltation using silt traps, solid waste removal using waste trap, flow tank for spill over, collection tank, sump from where the water will be pumped to the various locations and also for the excess water to be drained to the sea by a naturally controlled mechanism.
- Sanitation facility at new fishing harbour for the entire fishing village of Enayam. Bathing rooms.

The budgetary preliminary estimate for Environmental Management for proposed port, road and railway alignment during construction phase is Rs 292 Million (29 Crores) and the annual budgetary estimate during operational phase is Rs 20 Million

As for the social compensation and measures, the future Port Authority is encouraged to initiate many CSR activities for improving the way of living of people of Colachel-Enayam and other nearby villages in 2.0 km radii area in sectors like fisheries, agriculture, tourism, common infrastructure facilities, educational & medical facilities, sanitation & wastewater treatment, solid waste management, etc. CSR activities are also planned to achieve environmental standards:

A preliminary budget is included for the social measures proposed, excluding land acquisition cost, for port construction (reclamation) and implementation of the access road and railway corridors. The budgetary preliminary estimate for CSR measures for proposed port, road and railway alignment is Rs 950 Million (95 Crores).

Cost of CSR activities that include:

- Water Supply Scheme for Enayam fishing Village
- Rehabilitation of livelihood loses. Creation of a skill development centre in Enayam
- Implementation of a new fishing harbour in Enayam (equipped with cold store, sanitation and loading and unloading and distribution facilities and integration with new fishing harbour (rehabilitation of the existing fishing harbour) in Colachel
- General CSR activities, as compensation measures, in sectors like fisheries, agriculture, tourism, common infrastructure facilities, educational & medical facilities, sanitation & wastewater treatment, etc (provision of funds for social enhancing measures)

11.5. ENVIRONMENTAL AND SOCIAL FEASIBILITY

Also to ensure the social feasibility of the project and to ensure the quality of the population livelihood in the project area, this preliminary Environmental Examination states that important studies and plans should be finished and approved before the project was operational. Final ESIA Report should address these important issues, and the conclusions of these studies and plans should be translated into conditions into the final Project Design. It is then recommended that a set of Studies and Plans should be carried out before project implementation

- Risk Analysis

Addressing proposed project actions related risks associated with explosion, fire, or release of hazardous materials in the event of accident or a natural disaster with the construction and operation of the proposed port in terms of identifying the hazards and suggesting the suitable mitigation measures.

- Disaster Management Plan

A framework for Disaster Management Plan should be prepared to minimise damages in the event of a disaster. An On-Site Emergency Preparedness Plan and Off-Site Emergency Preparedness Plan must be broadly prepared to deal with emergencies and prevent disasters including an institutional framework with clear assignment of roles and responsibilities was broadly prepared with which location of Emergency Control Centre and Assembly Points to be identified.

- Spill Contingency Plan

An oil spill contingency plan for shall be prepared and approved by the Indian Coastguard. It would describe about the different organisation/ teams required and their responsibilities. It also covered training, inspection and drill schedule and equipment, etc. required effect function of contingency plan.

11.6. ENVIRONMENTAL MOEF CLEARENCE

Finally, the proposed Port Project is a Category A Project as the proposed cargo handling capacity is ≥ 5 million tonnes per annum (TPA). Hence, Environmental Clearance from the Ministry of Environment and Forest (MoEF), Government of India will be required as given in rule 2(II) of Annex I of the "EIA Notification" of The Environment (Protection) Act, 1986.

In further project development stages, a full comprehensive Environmental Social Impact Assessment Study should be carried out as per the MoEF's EIA Guidance Manual for Ports and Harbour along with the International Finance Corporation's (IFC) Performance Standards 2006, Environmental, Health and Safety (EHS) Guidelines for Ports, Harbour and Terminals, and EHS Guidelines for Construction Materials Extraction for obtaining the Clearance from MoEF.

12. ESTIMATION OF PROJECT CAPITAL COST

12.1. PRINCIPLES FOR COST ESTIMATION

This cost estimates are calculated in order to have an input on the CAPEX of the project and to be able to calculate its financial feasibility.

The following assumptions have been used:

- All costs are presented Rupees.
- Mobilization and demobilization costs are included in respective entities.
- Land costs have been obtained by requesting information from authorities and private companies. A deeper analysis must be developed to confirm these costs.
- Engineering and project management is added as 7.5 % of the project costs.
- Besides, 15% of the project costs have been included for contingencies.

Costs and rates are based on similar projects developed by TYPSA and BCG, and marine projects of south India, like Colachel fishing harbour, currently in progress. Some of the rates are "macro-rates", which means a rough estimate of a major unity.

Cost estimates have been broken down in the following sections:

- Preliminaries

This section includes all the preliminary studies and surveys (e.g. bathymetric or topographic surveys previous to the beginning of the construction), and some other works required before the main works begin. One important preliminary work is the temporary berthing facility which will allow the construction of the breakwater by maritime means.

- Breakwaters

As explained earlier, both rubble mound and vertical breakwaters have been proposed following a cost saving criteria. The following considerations have been assumed for rubble mound breakwaters:

- Rock layers porosity: 0.370
- Concrete cubes layer porosity: 0.470
- Accropods layers porosity: 0.491

Regarding vertical breakwaters, the following assumptions have been taken for caisson construction and installation:

- 20% of total volume of caisson is reinforced concrete and 80% is sand fill.
- Reinforcement steel rate is 100 kg/m^3 of concrete.

Berths

The cost estimates have been made considering the basic design of an open pile berthing structure, assuming a 9 m x 9 m grid and mean length of 35 m for piles, with stone pitching as slope protection underneath the berth. Also, a mean thickness of 1.0 m for reinforced concrete superstructure has been considered, with a reinforcement steel rate of 120 kg/m^3.

Berth equipment such fenders, bollards, ladders or mooring rings have been considered. Both fenders and bollards have been assumed to be located every15 m.

STS rails (A150) and fixtures (pads, clips, plates, bolts, etc) have been considered along the container berth as well.

Dredging and reclamation

This section includes the dredging costs to obtain the required drafts for the basin, the berth pocket and the approach channel. It also includes the costs for land reclamation, which is assumed to be done through dredging from surrounding areas of Phase 2 and 3 of the port. Finally, the ground improvement of reclaimed areas has been included too.

Reclamation for port related industrial areas has been included but no ground improvement or pavement has been considered. Instead of it, ground improvement costs are only estimated over the yard areas of the port.

A breakdown of quantities on dredging and reclamation is included in clause 9.5.

Rates for dredging include equipment mobilization, demobilization and service tax (14.42%).

Yards

Pavement design has been estimated in different areas. Three zones have been studied:

- Container yard-Stacking area:

  80 mm thickness concrete block paving + 30 mm laying course material + 470 mm cement bound granular mixture C8/10 + 450 mm aggregate sub-base + 900 mm capping layer
- Container yard-Operation area:

  80 mm thickness concrete block paving + 30 mm laying course material + 560 mm cement bound granular mixture C8/10 + 450 mm aggregate sub-base + 900 mm capping layer
- Multipurpose area:

  240 mm concrete C32/40+ 150 mm aggregate sub-base + 900 mm capping layer

The design has been performed in accordance to "The Structural Design of Heavy Duty Pavements for Ports and Other Industries" (NTERPAVE -4th Edition: 2007), based on British Standards and broadly used for this kind of ports.

ARMG concrete beams, rails (MRS 87A) and fixtures have been considered in container yard too.

Equipment

The quantities included in this section are the required so that the terminal is working at full capacity in 2020.

Buildings

A rough estimate of buildings has been made in this section. Four entities are included, depending on the type of building.

- Administrative and operation buildings: Port administrative building, private operator administrative building, port and yard operations buildings.
- Maintenance buildings: Cranes maintenance and others repair buildings,
- Utility Buildings: Fire station, electrical sub stations, fuel station, reefer shop and other utility buildings.
- Miscellaneous buildings: Canteen, quay workers restrooms, security booths, and others.

A rate per square meter has been assigned to each type of building, as can be seen in the cost estimates table.

Networks and utilities

Networks include not only roads and railways inside the port area, but gates and parking areas. The main utilities, such us power and water supply, water drainage and sewage, or communications are included too.

Regarding Aids to Navigation and VTMS, cost estimates have been calculated following clause 9.4.

Connectivity

Infrastructures to link the port to the main transport networks are included here. Macro-rates per each kilometre are used to estimate the cost for them. These rates take into account the land relief and the expected amount of structures (bridges, viaducts or tunnels). The total lengths for road and railway links are obtained from the drawings.

Land acquisition

Taking into account their typical cross sections, a corridor of 60 m for the new 4-lane road and 40 m for the new 2-track railway is assumed to estimate land acquisition costs. The mean value of land cost has been calculated based on the specific rates given in section 7.5.

A specific feasibility study for connectivity should be made to assess accurately these costs.

12.2. TOTAL COST ESTIMATES

As a result of multiplying the obtained rates by the estimated quantities of each entity, the partial, section and total amount is obtained.

The following table shows the total cost estimates.

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
1	PRELIMINARIES								
1.1	Surveys and studies	L.S.	25,200,000.00	1	2.52	0.25	0.63	0.25	0.63
1.2	Site Clearance, site offices, fencing	L.S.	22,050,000.00	1	2.21	1	2.2	1	2.21
1.3	Temporary berthing facilities	L.S.	189,000,000.00	1	18.9	0	0	0	0
	Total				23.63		2.84		2.84
2	BREAKWATERS								
2.1	Rubble mound breakwater								
2.1.1	Core material (50-100 kg)	Cu.m	1,890.00	704,839.10	133.21	134,967.32	25.51	134,967.32	25.51
2.1.2	Rock (1-50 kg)	Cu.m	1,890.00	16,922.31	3.2	3,933.97	0.74	3,933.97	0.74
2.1.3	Rock (0.2-0.5 t)	Cu.m	2,835.00	22,785.08	6.46				
2.1.4	Rock (0.5-1 t)	Cu.m	3,465.00	49,932.29	17.3	0	0	0	0
2.1.5	Rock (3-4 t)	Cu.m	5,040.00	24,924.16	12.56	24,924.16	12.56	24,924.16	12.56
2.1.8	Concrete cubes (5 t)	Cu.m	8,820.00	3,865.17	3.41	0	0	0	0
2.1.9	Accropods (2 m^3)	Cu.m	10,710.00	3,751.84	4.02	0	0	0	0
2.1.10	Accropods (3 m^3)	Cu.m	11,340.00	33,123.28	37.56	0	0	0	0
2.1.11	Superstructure *(Crown wall)*	Cu.m	12,600.00	40,232.64	50.69	0	0	0	0

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
2.2	Vertical Breakwater								
2.2.1	Bedding layer (50-150 kg)	Cu.m	1,890.00	269,185.01	50.88	274,386.44	51.86	191,237.21	36.14
2.2.2	Rock protection (1-2 t)	Cu.m	3,465.00	72,115.94	24.99	71,731.07	24.85	49,993.90	17.32
2.2.4	Guard blocks (36 t)	Cu.m	11,970.00	15,036.00	18	0.63	0	0.44	0
2.2.5	Caissons								
2.2.5.1	Structure (reinforced concrete)	Cu.m	23,940.00	240,643.52	576.1	160,942.02	385.3	112,170.64	268.54
2.2.5.2	Sinking on site	L.S.	220,500,000.00	1	22.05	0.63	13.98	0.44	9.74
2.2.5.3	Sand fill	Cu.m	630	962,574.08	60.64	643,768.09	40.56	448,682.55	28.27
2.2.6	Superstructure *(Crown wall)*	Cu.m	12,600.00	81,967.50	103.28	41,316.08	52.06	28,795.78	36.28
	Total				1,124.35		611.46		439.15
3	BERTHS								
3.1	Container berth (35 m wide)								
3.1.1	Concrete Piles (1500 mm)	m	113,400.00	16,520.00	187.34	41,300.00	468.34	24,780.00	281.01
3.1.2	Superstructure	Sq.m	26,775.00	29,750.00	79.66	74,375.00	199.14	44,625.00	119.48
3.1.3	Berth equipment								
3.1.3.1	Fenders	Un	2,835,000.00	57	16.16	143	40.54	86	24.38

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
3.1.3.2	Bollards and misc.	L.S.	18,900,000.00	1	1.89	2.5	4.73	1.5	2.84
3.1.3.3	STS Rails and fixtures	m	63,000.00	1,600.00	10.08	4,000.00	25.2	2,400.00	15.12
3.1.4	Slope protection under berth								
3.1.4.1	Filter (1-50 kg)	Cu.m	1,890.00	14,029.08	2.65	35,072.70	6.63	21,043.62	3.98
3.1.4.2	Armourstone (0.5-1 t)	Cu.m	3,465.00	43,591.63	15.1	108,979.08	37.76	65,387.45	22.66
3.2	Multipurpose berth (20 m wide)								
3.2.1	Concrete Piles (1200 mm)	m	94,500.00	4,655.00	43.99	0	0	0	0
3.2.2	Superstructure	Sq.m	26,775.00	8,000.00	21.42	0	0	0	0
3.2.3	Berth equipment						0		
3.2.3.1	Fenders	Un	2,520,000.00	27	6.8	0	0	0	0
3.2.3.2	Bollards and misc.	L.S.	6,300,000.00	1	0.63	0	0	0	0
3.2.4	Slope protection under berth								
3.2.4.1	Filter (1-50 kg)	Cu.m	1,890.00	5,078.22	0.96	0	0	0	0
3.2.4.2	Armourstone (0.5-1 t)	Cu.m	3,465.00	15,779.21	5.47	0	0	0	0

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
3.3	Ancillary berth (20 m wide)							0	0
3.3.1	Concrete Piles (1200 mm)	m	94,500.00	2,345.00	22.16	0	0	0	0
3.3.2	Superstructure	Sq.m	26,775.00	4,000.00	10.71	0	0	0	0
3.3.3	Berth equipment						0		
3.3.3.1	Fenders	Un	315,000.00	20	0.63	0	0	0	0
3.3.3.2	Bollards and misc.	L.S.	3,150,000.00	1	0.32	0	0	0	0
3.3.4	Slope protection under berth								
3.3.4.1	Filter (1-50 kg)	Cu.m	1,890.00	2,539.11	0.48	0	0	0	0
3.3.4.2	Armourstone (0.5-1 t)	Cu.m	3,465.00	7,889.61	2.73	0	0	0	0
3.4	Solid bulk berth (35 m wide)								
3.4.1	Concrete Piles	m	94,500.00	0	0	16,520.00	156.11	20,650.00	195.14
3.4.2	Superestructure	Sq.m	50,400.00	0	0	29,750.00	149.94	37,187.50	187.43
3.4.3	Berth equipment								
3.4.3.1	Fenders	Un	2,835,000.00	0	0	57	16.16	71	20.13
3.4.3.2	Bollards and misc.	L.S.	9,450,000.00	0	0	1	0.95	1.25	1.18

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
3.4.4	Slope protection under berth								
3.4.4.1	Filter (1-50 kg)	Cu.m	1,890.00	0	0	14,029.08	2.65	17,536.35	3.31
3.4.4.2	Armourstone (0.5-1 t)	Cu.m	3,465.00	0	0	43,591.63	15.1	54,489.54	18.88
	Total				429.18		1,123.25		895.53
4	DREDGING AND RECLAMATION								
4.1	Reclamation bunds								
4.1.1	Core material (50-100 kg)	Cu.m	1,890.00	1,384,731.15	261.71	1,736,340.00	328.17	1,041,804.00	196.9
4.1.2	Filter (1-50 kg)	Cu.m	1,890.00	29,013.05	5.48	36,380.00	6.88	21,828.00	4.13
4.1.3	Armourstone (1-2 t)	Cu.m	3,780.00	95,333.15	36.04	119,540.00	45.19	71,724.00	27.11
4.2	Dredging of sand and pumping into reclaim. area	Cu.m	491.4	6,819,280.00	335.1	6,332,623.00	311.19	1,821,258.00	89.5
4.3	Dredging of sandbank and pumping into reclaim. area	Cu.m	491.4	3,303,992.65	162.36	9,562,159.00	469.88	6,395,527.00	314.28
4.4	Ground improvement	Sq.m	126	668,766.00	8.43	954,109.00	12.02	530,395.00	6.68
	Total				809.12		1,173.32		638.59
5	YARDS								
5.1	Container Yard-Stacking & Operation area								
5.1.1	Concrete block paving + laying course material	Sq.m	882	410,769.00	36.23	922,426.00	81.36	530,395.00	46.78

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
5.1.2	Cement Bound Granular Mixture $C_{8/10}$	Cu.m	5,166.00	213,599.88	110.35	479,661.52	247.79	275,805.40	142.48
5.1.3	Aggregate sub-base	Cu.m	1,575.00	184,846.05	29.11	415,091.70	65.38	238,677.75	37.59
5.1.4	Capping layer	Cu.m	945	369,692.10	34.94	830,183.40	78.45	477,355.50	45.11
5.1.5	ARMG Rail and fixtures	m	44,100.00	11,748.00	51.81	26,381.00	116.34	15,169.00	66.9
5.1.6	ARMG beams (Reinf. Concr.)	Cu.m	23,940.00	6,408.00	15.34	14,390.00	34.45	8,274.00	19.81
5.2	Multi-purpose Area			257,997.00		31,683.00		0	
5.2.1	Concrete $C_{32/40}$	Cu.m	7,875.00	61,919.28	48.76	7,603.92	5.99	0	0
5.2.2	Aggregate sub-base	Cu.m	1,575.00	28,650.00	4.51	4,752.45	0.75	0	0
5.2.3	Capping layer	Cu.m	945	171,900.00	16.24	28,514.70	2.69	0	0
	Total				347.29		633.2		358.67
6	EQUIPMENT								
6.1	Container Terminal								
6.1.1	STS Cranes (Quay)	Un	630,000,000.00	9	567	22	1,386.00	14	882
6.1.2	A-RMG Cranes (Yard)	Un	126,000,000.00	44	554.4	110	1,386.00	66	831.6
6.1.3	RMG Cranes (Rail yard)	Un	157,500,000.00	2	31.5	4	63	2	31.5

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
6.1.4	Shuttle Carriers	Un	53,550,000.00	16	85.68	40	214.2	24	128.52
6.1.5	Reach Stackers	Un	31,500,000.00	2	6.3	5	15.75	3	9.45
6.1.6	Terminal tractors	Un	6,300,000.00	4	2.52	10	6.3	6	3.78
6.2	Coal Yard								
6.2.1	Gantry Cranes (Quay)	Un	630,000,000.00	0	0	2	126	2	126
6.2.2	Stackers, reclaimers, conveyors	L.S.	126,000,000.00	0	0	1	12.6	1	12.6
	Total				1,247.40		3,209.85		2,025.45
7	BUILDINGS								
7.1	Admin. and Operation Buildings	Sq.m	35,280.00	2,600.00	9.17	1,300.00	4.59	650	2.29
7.2	Maintenance Buildings	Sq.m	28,980.00	4,500.00	13.04	4,500.00	13.04	2,250.00	6.52
7.3	Utility Buildings	Sq.m	34,650.00	1,000.00	3.47	0	0	0	0
7.4	Miscellaneous Buildings	Sq.m	22,050.00	800	1.76	0	0	0	0
	Total				27.44		17.63		8.81

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
8	NETWORKS AND UTILITIES								
8.1	Gates	L.S.	63,000,000.00	1	6.3	1	6.3	0	0
8.2	Internal railway	L.S.	226,800,000.00	1	22.68	1	22.68	0.5	11.34
8.3	Electric supply and lighting	L.S.	630,000,000.00	1	63	0.1	6.3	0.1	6.3
8.4	Water supply and fire fighting	L.S.	100,800,000.00	1	10.08	0.5	5.04	0.5	5.04
8.5	Water sewage and drainage	L.S.	189,000,000.00	1	18.9	0.5	9.45	0.5	9.45
8.6	Communications and IT	L.S.	63,000,000.00	1	6.3	0.5	3.15	0.5	3.15
8.7	Aids to navigation	L.S.	22,050,000.00	1	2.21				
8.8	VTMS	L.S.	15,750,000.00	1	1.58	0	0	0	0
	Total				131.04		52.92		35.28
9	CONNECTIVITY								
9.1	Road connectivty	km	126,000,000.00	11.8	148.68	0	0	0	0
9.2	Railway connectivty	km	126,000,000.00	9.9	124.74	0	0	0	0
	Total				273.42		0		0

	ITEM	UNIT	RATE (Rs)	PHASE 1		PHASE 2		PHASE 3	
				QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)	QUANTITY	AMOUNT (Rs.Cr.)
11	LAND AQUISITION								
11.1	Road (60 m wide corridor)	Ha	6,300,000.00	70.2	44.23	0	0	0	0
11.2	Rail (40 m wide corridor)	Ha	6,300,000.00	42	26.46	0	0	0	0
	Total				70.69		0		0
	TOTAL				4,483.55		6,824.47		4,404.32
	OTHERS								
	Engineering and PMC	%	7.50%		336.27		511.84		330.32
	Provision for contingencies	%	15%		672.53		1,023.67		660.65
	GRAND TOTAL				5,492.35		8,359.98		5,395.29

13. FINANCIAL ASSESSMENT

13.1. Key Assumptions

The key assumptions used in the financial model to evaluate the financial viability of the project have been highlighted below.

13.1.1. Timelines

The financial model has been built for three options for the concession period: 20 years, 25 years and 30 years. The construction period for each phase has been assumed to be 3 years.

13.1.2. Project Cost Estimates

The project cost estimates for each of the three phases is presented in the table below. The project cost estimates comprise of the base capital costs, cost escalation due to the above phasing and other preliminary expenses including interest during construction and syndication fee. These cost estimates and capacity of each phase have been updated after the submission of 'Report on Alternative Development Concepts and Location of the Port' and details of the revised cost estimate will be provided in the final report. The escalation in capital cost has been taken as 4.7% per annum based on the CAGR of Construction Cost Indices (2007-2015) for infrastructure projects (published by Construction Industry Development Council, Government of India).

		(all figures in INR crores)	
Component	Phase 1	Phase 2	Phase 3
Preliminaries	23.6	2.8	2.8
Breakwaters	1,124.4	611.5	439.2
Berth	429.2	1,123.3	895.5
Dredging and Reclamation	809.1	1,173.3	638.6
Yards	347.3	633.2	358.7
Equipments	1,247.4	3,209.9	2,025.5
Buildings	27.4	17.6	8.8
Network and Utilities	131.0	52.9	35.3
Connectivity	273.4	0.0	0.0
Land Acquisition	70.7	0.0	0.0
Port Crafts	0.0	0.0	0.0
Total Civil Cost	4,483.6	6,824.5	4,404.3
Engineering and project management	336.3	511.8	330.3
Provision for contingencies	672.5	1,023.7	660.6
Escalation	347.5	2,237.3	3,173.1
Total Construction Cost	5,839.8	10,597.3	8,568.4
Interest During Construction	689.3	877.7	823.3
Syndication Fees	46.0	61.9	66.2
Total Project Cost for Phase	6,575.2	11,536.9	9,457.9

Table 43: Summary of Phase-wise Project Cost

13.1.3. Traffic Projection

The traffic projections included in the Traffic and Market Study Report has used in the financial analysis and has been further detailed out in the table below.

Hazardous & Reefer containers have been assumed to be 5%, while Loaded and Empty containers have been assumed in the ratio of 85%:15% based on the existing traffic at Chennai and Tuticorin Port. TEU per container ratio has been assumed to be 1.5 for estimating the number of 20' and 40' containers.

(all figures in million TEUs)

Year	Total Container Traffic	Trans-shipment		Gateway		
		Regular Containers	Hazardous & Reefers	Loaded	Empty	Hazardous & Reefers
2018	1.00	0.36	0.02	0.50	0.09	0.03
2019	1.32	0.49	0.03	0.65	0.11	0.04
2020	1.69	0.64	0.03	0.82	0.15	0.05
2021	2.22	0.91	0.05	1.02	0.18	0.06
2022	3.00	1.35	0.07	1.28	0.23	0.08
2023	3.72	1.88	0.10	1.40	0.25	0.09
2024	4.29	2.27	0.12	1.53	0.27	0.09
2025	4.91	2.70	0.14	1.67	0.29	0.10
2026	5.24	2.87	0.15	1.79	0.32	0.11
2027	5.58	3.05	0.16	1.92	0.34	0.12
2028	5.94	3.24	0.17	2.05	0.36	0.13
2029	6.33	3.44	0.18	2.19	0.39	0.14
2031	6.74	3.66	0.19	2.33	0.41	0.14
2032	7.08	3.84	0.20	2.45	0.43	0.15
2033	7.08	3.84	0.20	2.45	0.43	0.15
2034	7.08	3.84	0.20	2.45	0.43	0.15
2035	7.08	3.84	0.20	2.45	0.43	0.15
2036	7.08	3.84	0.20	2.45	0.43	0.15
2037	7.08	3.84	0.20	2.45	0.43	0.15
2038	7.08	3.84	0.20	2.45	0.43	0.15
2039	7.08	3.84	0.20	2.45	0.43	0.15
2040	7.08	3.84	0.20	2.45	0.43	0.15
2041	7.08	3.84	0.20	2.45	0.43	0.15
2042	7.08	3.84	0.20	2.45	0.43	0.15
2043	7.08	3.84	0.20	2.45	0.43	0.15
2044	7.08	3.84	0.20	2.45	0.43	0.15

Table 44: Container traffic projection

(all figures in million containers)

Year	Total Container Traffic	Trans-shipment				Gateway						
		Regular Containers		Hazardous & Reefers		Loaded		Empty		Hazardous & Reefers		Container vessels
		20'	40'	20'	40'	20'	40'	20'	40'	20'	40'	
2018	0.66	0.12	0.12	0.01	0.01	0.17	0.17	0.03	0.03	0.01	0.01	144
2019	0.88	0.16	0.16	0.01	0.01	0.22	0.22	0.04	0.04	0.01	0.01	189
2020	1.13	0.21	0.21	0.01	0.01	0.27	0.27	0.05	0.05	0.02	0.02	241
2021	1.48	0.30	0.30	0.02	0.02	0.34	0.34	0.06	0.06	0.02	0.02	320
2022	2.00	0.45	0.45	0.02	0.02	0.43	0.43	0.08	0.08	0.03	0.03	437
2023	2.48	0.63	0.63	0.03	0.03	0.47	0.47	0.08	0.08	0.03	0.03	551
2024	2.86	0.76	0.76	0.04	0.04	0.51	0.51	0.09	0.09	0.03	0.03	637
2025	3.27	0.90	0.90	0.05	0.05	0.56	0.56	0.10	0.10	0.03	0.03	731
2026	3.49	0.96	0.96	0.05	0.05	0.60	0.60	0.11	0.11	0.04	0.04	774
2027	3.72	1.02	1.02	0.05	0.05	0.64	0.64	0.11	0.11	0.04	0.04	818
2028	3.96	1.08	1.08	0.06	0.06	0.68	0.68	0.12	0.12	0.04	0.04	865
2029	4.22	1.15	1.15	0.06	0.06	0.73	0.73	0.13	0.13	0.05	0.05	913
2030	4.49	1.22	1.22	0.06	0.06	0.78	0.78	0.14	0.14	0.05	0.05	965
2031	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	1,007
2032	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	1,000
2033	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	993
2034	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	985
2035	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	979
2036	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	972
2037	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	966
2038	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	959
2039	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	953
2040	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	946
2041	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	940
2042	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	933
2043	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	927
2044	4.72	1.28	1.28	0.07	0.07	0.82	0.82	0.14	0.14	0.05	0.05	921

Table 45: Distribution of container traffic

Based on the existing coal traffic at Tuticorin Port and discussions with Power sector experts, it is expected that 30% of coal would be imported and 70% indigenous. The indigenous coal is expected to be transported in Handymax and Panamax vessels, while the imported coal is expected to be transported in Panamax and Capesize vessels, considering the vessel trends and draft at Paradip, Haldia and Vizag ports for indigenous and Indonesian ports for imported coal.

Year	Coal traffic (mn Tonne)	Vessels		
		Handymax	Panamax	Capesize
2018	0.0	0	0	0
2019	0.0	0	0	0
2020	0.0	0	0	0
2021	0.0	0	0	0
2022	1.1	3	7	3
2023	2.2	7	14	5
2024	3.3	10	21	8
2025	3.3	10	21	8
2026	3.3	8	19	9
2027	4.4	11	25	12
2028	5.5	13	32	15
2029	6.6	16	38	18
2030	6.6	16	38	18
2031	6.6	16	38	18
2032	6.6	16	38	18
2033	6.6	16	38	18
2034	6.6	16	38	18
2035	6.6	16	38	18
2036	6.6	12	35	22
2037	6.6	12	35	22
2038	6.6	12	35	22
2039	6.6	12	35	22
2040	6.6	12	35	22
2041	6.6	12	35	22
2042	6.6	12	35	22
2043	6.6	12	35	22
2044	6.6	12	35	22

Table 46: Coal traffic projection

13.1.4. Tariff structure

During the traffic study, it has been established that for Colachel port to be competitive with Colombo Port, the charges for Trans-shipment traffic need to matched. Hence, for this analysis, the charges for Trans-shipment traffic have been assumed as per the Scale of Rates of Colombo Port. In addition, we have assumed a discount of 15% on the above tariff for the first 5 years.

For Gateway Container and Coal traffic, the charges for Chennai, Tuticorin and Cochin port were compared. For gateway traffic, the port can fix higher charges as seen in globally for ports with a mix of trans-shipment and gateway traffic. Hence, the charges in the financial model have been assumed as per Cochin Port's scale of rates, since they were higher than Chennai and Tuticorin Port. Despite the higher rates, Enayam will be able to attract traffic compared to Tutcorin, because there will be overall logistic cost saving over Tuticorin due to higher productivity and since the exporters and importers will save on one set of port charges by coming directly to Enayam.

The detailed tariff structure is provided in the tables below.

Vessel related charges (Trans-shipment)		
Port Dues		
Light dues	2.0	INR per GRT
Entering dues	2.7	INR per GRT
Pilotage		
Pilotage dues	2.7	INR per GRT
Pilot fee (up to 30,000 DWT)	1,440	INR per move
Pilot fee (above 30,000 DWT)	1,920	INR per move
Tug services charge	9,660	INR per tug
Moves per call for pilotage	50	
Tug per call	10	
Berth Hire/ Dockage		
Berth Hire charges	0.13	INR per GRT per hour
Average Berth Occupancy time	25	hours
Cargo related charges (Trans-shipment)		
Terminal Handling Costs		
20' container	2,220	INR per container
40' container	3,450	INR per container
Storage charges		
First 21 days	0	INR per day
Thereafter	312.0	INR per day

Table 47: Tariff structure for Trans-shipment traffic

In order to attract traffic in the first few years, we have assumed a discount of 15% on the above tariff for the first 5 years.

Vessel related charges (Gateway)			
	Coastal	Foreign	
Port Dues	9.6	21.5	INR per GRT
Pilotage Fees			
Upto 30000 GRT	20.9	46.7	INR per GRT
30000 - 60000 GRT	16.7	37.4	INR per GRT
Above 60000 GRT	14.6	32.7	INR per GRT
Berth Hire Charges	0.17	0.33	INR per GRT per hour
Average Berth Occupancy time	25	hours	
Cargo related charges (Gateway)			

Container Handling and Transportation charges (all inclusive)			
	Coastal	Foreign	
Loaded			
20'	3,221	5,058	INR per container
40'	4,831	8,078	INR per container
Empty			
20'	2,260	4,182	INR per container
40'	3,390	6,274	INR per container
Hazardous			
20'	4,025	6,730	INR per container
40'	6,040	10,110	INR per container
Reefer - Electricity Supply and Monitoring charges			
20'	312	413	INR per container
40'	526	692	INR per container
Wharfage charges			
	Coastal	Foreign	
Loaded			
20'	507	846	INR per container
40'	761	1,269	INR per container
Empty			
20'	107	178	INR per container
40'	160	266	INR per container
Storage charges (Gateway)			
	Coastal	Foreign	
Loaded (20')			
First 7 days	0	0	INR per container per day
8th to 15th day	279	385	INR per container per day
16th to 30th day	558	769	INR per container per day
Thereafter	1,117	1,537	INR per container per day
Loaded (40')			
First 7 days	0	0	INR per container per day
8th to 15th day	559	769	INR per container per day
16th to 30th day	1,117	1,538	INR per container per day
Thereafter	2,234	3,074	INR per container per day
Empty (20')			
First 3 days	0	0	INR per container per day
4th to 10th day	279	385	INR per container per day
11th to 35th day	558	769	INR per container per day
Thereafter	1,117	1,537	INR per container per day
Empty (40')			
First 3 days	0	0	INR per container per day
4th to 10th day	559	769	INR per container per day
11th to 35th day	1,117	1,538	INR per container per day
Thereafter	2,234	3,074	INR per container per day

Table 48: Tariff structure for Gateway Container traffic

Cargo related charges (Coal)			
Wharfage charges	56	INR per Tonne	
Vessel related charges (Coal)			
	Coastal	Foreign	
Port Dues	7.7	17.2	INR per GRT
Pilotage Fees			
Upto 30000 GRT	21.5	48.2	INR per GRT
30000 - 60000 GRT	17.2	38.6	INR per GRT
Above 60000 GRT	15.1	33.7	INR per GRT
Berth Hire Charges	0.15	0.29	INR per GRT per hour
Average Berth Occupancy time	55	hours	

Table 49: Tariff structure for Coal traffic

The escalation rate for tariff has been taken as per the Wholesale Price Index (WPI). The CAGR for WPI from 2004 to 2014 is 6.6%. The escalation rate has been tapered down over the concession period, from 6% in first 15 years to 5.5% in the last 15 years.

13.1.5. Operation and Maintenance costs

For the purpose of estimation, O&M cost has been bifurcated into following six broad components:

- Power charges
- Fuel charges
- Repair & maintenance
  - Civil
  - Equipment
- Insurance expenses
- Labour cost, Salary and Administrative Cost

The assumptions for the first five components have been assumed as per the prescribed guidelines of 'Tariff Authority for Major Ports (TAMP)', while for the last component, the value has been assumed as per the global BCG benchmarks of existing container-based ports.

They key assumptions for these components are provided in the table below.

Power for Container	8.00 kwh/TEU
Fuel (Diesel) for Container	4.00 ltrs/TEU
Power for Coal traffic	1.40 kwh/Tonne
Cost of Power	6.35 INR/ kwh

Cost of Diesel	52.76 INR/ ltr
Repair & Maintenance - Civil	1.0% of civil assets
Repair & Maintenance - Equipment	2.0% of equipments
Insurance	1.0% of gross fixed assets
Labour, salary and Administrative Cost	40.0% of total O&M Cost

Table 50: O&M cost assumptions

The escalation rate for O&M costs has been taken as per the Wholesale Price Index (WPI). The CAGR for WPI from 2004 to 2014 is 6.6%. The escalation rate has been tapered down over the concession period, from 6% in first 15 years to 5.5% in the last 15 years.

13.1.6. Funding structure

The funding structure has been assumed as per industry benchmarks for port projects that developed through private sector participation. A debt-equity ratio of 70:30 has been assumed. Other details of the funding structure are provided in the table below.

Debt: Equity	70:30
Interest Rate	12.5%
Moratorium	3 years
Repayment Period	12 years
Syndication Fee	1.0%
Cost of Equity	16 - 18%
WACC	10.6%

Table 51: Assumptions for Funding Structure

The interest rate and debt terms have been used as per the terms of commercial lending by Indian banks for large infrastructure projects. In case, government is able to procure funding from multilateral and bilateral agencies such as ADB, World Bank, JICA etc., the interest rates could be around 1 - 3% and the payback period could be up to 30 years. The VGF required in that case, maintaining an equity IRR of 16-18%, will be to the tune of 10-15%. The financial model has been made flexible to adjust the debt-equity ratio and cost of capital.

13.1.7. Tax and Depreciation

The assumptions for taxation structure are as follows:

Corporate Tax rate	33.99%
Minium Alternate Tax (MAT) rate	20.96%
Carry forward of losses	8 years

Carry forward of MAT	10 years

Table 52: Tax assumptions

The depreciation for P&L statement has been calculated as per straight line method and the depreciation rates have been taken as per the latest Companies Act. For taxation purposed, the depreciation has also been calculated as per the written down value method and the depreciation rates for this method has been taken as per the Income Tax Act. The depreciation rates are as follows:

Companies Act (SLM)	
Building (Phase 1)	3.70%
Building (Phase 2)	4.17%
Building (Phase 3)	5.26%
Plant & Machinery	12.5%
Pre-operating expenses (amoritisation)	10.0%
IT Act (WDV)	
Building	10.0%
Equipments	15.0%
Pre-operating expenses (amoritisation)	20.0%

Table 53: Depreciation rates

The key assumptions are summarised below.

Timelines	
Concession Period	30 years
Start Year	2015
Operation Start Year	2018
Concession End Year	2044
Phase 1	2018-20
Phase 2	2021-25
Phase 3	2026-30
Tariff structure	
Trans-shipment Traffic	As per Colombo Port's Scale of Rates *(15% discount provided for the first 5 years)*
Gateway Traffic	As per Cochin Port's Scale of Rates
Funding structure	
Debt	70.00%
Interest Rate	12.50%
Moratorium	3 years
Repayment Period	12 years
Syndication Fee	1.00%
Cost of Equity	16 -18%
WACC	10.60%

13.2. FINANCIAL RESULTS

This section presents the summary of results of the financial analysis after running the financial model using projected traffic figures and industry benchmarks for port projects. The financial analysis identifies and estimates various revenue streams, project costs, phasing or implementation schedule, cash flows and the financial viability of the project. The financial analysis of the Enayam Port is based on set of assumptions and inputs based on the industry benchmarks and from analysis & experience in the Port sector in India and globally. A detailed financial model has been developed for a Concession period of 30 years; the financial viability of the project has been assessed on the Discounted Cash Flow (DCF) and Internal Rate of Returns (IRR) method.

The key results of the discounted cash flow analysis based on the above mentioned assumptions are as follows:

NPV	INR 380 Crores
Project IRR	10.8%
Equity IRR	11.0%
Phase 1 Project IRR	9.2%
Phase 1 Equity IRR	8.6% 1[1]

Table 54: Financial results

As can be seen in the results above, the project IRR is above WACC of 10.6%, but the equity IRR is lower than the cost of equity of 16-18%. In order to make the project financially viable, viability gap funding (VGF) will be required. It has been estimated that a VGF of 20-30% is required to achieve the target equity IRR of 16-18%.

Further, it can be seen that the difference between the project IRR and equity IRR value is low. This is because the value of project IRR is very close to WACC. Despite the low difference in IRR values, it is advisable to take debt because of the large amount of capital expenditure required across the three phases and the difference between cost of debt and equity will be much large in terms of actual value, which the IRR value does not indicate.

On a standalone basis Phase 1 Project IRR (9.2%) is lower than overall IRR as benefits of the initial investments in breakwater, connectivity, reclamation etc. are not completely realized within Phase 1 only. Hence, it is advised that financial returns from the entire project are considered instead of returns from only Phase 1 in isolation.

The detailed P&L statement and cash flows (capital expenditure, interest payment and debt repayment), used in arriving at the above results, have been provided in the Annexures.

13.3. SENSITIVITY ANALYSIS

[1] EIRR is lower than Project IRR for Phase 1 as the Project IRR itself is lower than the Cost of Debt.

Concession Period, Revenue, O&M cost and capital costs are key parameters that affect the Equity IRR value. Further, it is important to understand the sensitivity of revenues from Trans-shipment and Gateway container traffic. The tables below highlight the impact of increase and decrease in these parameters by 5% and 10% and their combination.

Concession Period		
30 years	25 years	20 years
11.0%	9.8%	3.2%

Table 55: Sensitivity of Equity IRR to Concession Period

Revenue – Capex					
	(10.0%)	(5.0%)	0.0%	5.0%	10.0%
(10.0%)	10.0%	11.3%	12.6%	13.8%	15.0%
(5.0%)	9.3%	10.5%	11.8%	12.9%	14.1%
0.0%	8.6%	9.8%	11.0%	12.1%	13.3%
5.0%	7.9%	9.2%	10.3%	11.4%	12.5%
10.0%	7.4%	8.5%	9.7%	10.7%	11.8%

Table 56: Sensitivity of Equity IRR to Revenue and Capex

Revenue - Opex					
	(10.0%)	(5.0%)	0.0%	5.0%	10.0%
(10.0%)	9.6%	10.8%	10.9%	13.1%	14.2%
(5.0%)	9.1%	10.3%	10.5%	12.6%	13.7%
0.0%	8.6%	9.8%	10.0%	12.1%	13.3%
5.0%	8.1%	9.3%	9.5%	11.7%	12.8%
10.0%	7.6%	8.8%	9.1%	11.2%	12.4%

Table 57: Sensitivity of Equity IRR to Revenue and Opex

Trans-shipment Revenue - Gateway Revenue					
	(10.0%)	(5.0%)	0.0%	5.0%	10.0%
(10.0%)	8.6%	8.9%	8.2%	9.5%	9.8%
(5.0%)	9.5%	9.8%	9.1%	10.4%	10.7%
0.0%	10.4%	10.7%	10.0%	11.3%	11.6%
5.0%	11.3%	11.6%	10.9%	12.1%	12.4%
10.0%	12.2%	12.4%	11.7%	13.0%	13.2%

Table 58: Sensitivity of Equity IRR to Trans-shipment Revenue & Gateway Revenue

13.4. ECONOMIC IMPACT OF THE PROJECT

Development of a new port can be a potential boost for the economy of the country. The port itself is a profitable entity which gives back to the economy in terms of tax payments, employment generation and re-investments in infrastructure. It also provides cost competitiveness to the local businesses that use the port for imports and exports; these businesses further add back to the economy in form of taxes, employment and investments. Colachel is a large scale port project; it is expected to drive economic growth in the country especially in the hinterland area. The following section discusses the nature of economic impact of Colachel and quantifies it.

13.4.1. Economic impact of the port

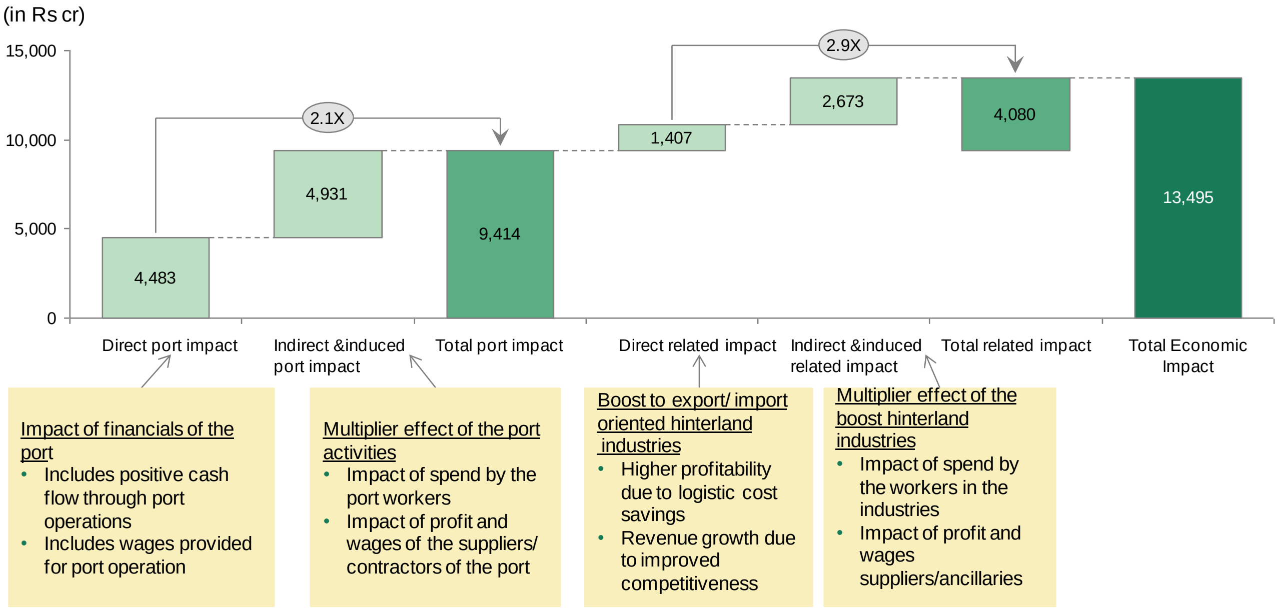
Colachel port will capture a substantial share of India's trans-shipment cargo which today gets trans-shipped in the foreign ports. It will also capture traffic from other countries in the region specially traffic from the Indian sub-continent countries. The cargo handling revenue generated by the port in 2030 is ~Rs 4,500 crore (it excludes revenue from traffic shifted from other Indian ports to Colachel); this is accounted as the direct economic impact of the port.

Additionally, the port operations will benefit the ancillary port based businesses including inland transportation businesses in the region. The port will also employ a large pool of employees for port operations. Impact on economy due to growth of ancillary industries and increased spending by port employees is accounted for in indirect impact of the port. This is estimated through an economic multiplier of 2.1. The economic multiplier is calculated based on economic impact studies for different port projects (E.g. Economic Impacts study of ports of Hamburg and Le Havre, Port of Auckland, South Carolina State Port etc.) and corrections made for the Indian context through BCG-TYPSA benchmarks. The indirect economic impact of the port is estimated to be ~ Rs 4900 crore in 2030.

13.4.2. Economic impact through businesses that would benefit from the port

The Colachel port will shift hinterland cargo which is currently getting trans-shipped in Colombo to direct gateway cargo through Colachel. This is primarily due to elimination of one leg of cargo handling in Colombo. This will reduce the logistics cost of the importers and exporters in the hinterland area (the chapter on traffic study discusses this in details). The logistics cost reduction accounts for Rs ~ 1,400 cr of savings for the related businesses in 2030. This will make them more competitive in the export markets and hence help grow their businesses further. It is estimated that the related industries will receive a profit boost of ~ Rs 1,500 cr (inclusive of wages, assuming a cost elasticity of trade of 0.8) in 2030. This further will have an indirect impact on the economy of ~ Rs 2,600 cr in 2030 (assuming an economic multiplier of 2.9 based on economic impact studies in India including Quantifying the Income and Employment Multipliers for Mumbai Region by National Council of Applied Economic Research)

The total economic impact of the project is estimated at ~Rs 13,500 cr in 2030. The following figure summarises the economic impact for the Colachel port project. Please note, this is an estimate arrived at on the basis of secondary studies; a further social-economic impact assessment study can be done for refining the economic impact estimates.



Source: BCG Analysis, Economic impact study of European ports – Hamburg and Le Havre, Economic Impact study of industries in Maharashtra

Figure 150: Economic impact of the port project

14. PROJECT STRUCTURE

14.1. MODELS FOR PRIVATE SECTOR PARTICIPATION

In order to implement the project, various models for private sector participation have been considered. There are broadly four models, based on ownership, responsibility for operations and risk allocation. These models have been summarized below in order of increasing private sector participation in the port.

		Public	Hybrid Models		Private
		Public service	**Management Contract Model**	**Landlord model (Concessionaire)**	**Private - Master Concessionaire**
Ownership	Port entity / infrastructure/ Master planning	Public Authority	Public Authority	Public Authority	Private player
Ownership	Equipments	Public Authority	Public Authority	Private player	Private player
Ownership	Ware-house infrastructure	Public Authority	Public Authority	Public or Private	Private player
Ownership	Connectivity infrastructure	Public Authority	Public Authority	Public Authority	Public or Private
Operations	Channel and access (dredging, navigation)	Public Authority	Public Authority	Public Authority	Private player
Operations	Terminal operations	Public Authority	Private player	Private Player	Private player
Operations	Warehouse mgmt.	Public Authority	Public or Private	Public or Private	Private player
Risks	Capital Risk	Public Authority	Public Authority	Shared	Private player
Risks	Volume Risk	Public Authority	Public Authority	Public or Private	Private player
Risks	Pricing Risk	Public Authority	Public Authority	Public or Private	Private player
		Dominant model pre 80s	Few examples in 80's and 90's	Popular model in recent years	Selectively used

Figure 151: Models for private sector participation

In recent times, landlord model has been the most popular model. Authorities have also used Master Concessionaire model in cases where the role of a strong port operator is important in achieving success either to build traffic or achieve high levels of productivity.

The next section talks about the key objectives that have been considered in order to arrive at suitable project structure models for Enayam.

14.2. KEY OBJECTIVES

While selecting a suitable model, it is important to balance the objectives of the government and mitigate the risks of private players. The figure below discusses the common priority objectives of the government and how these are fulfilled in each of the PPP model.

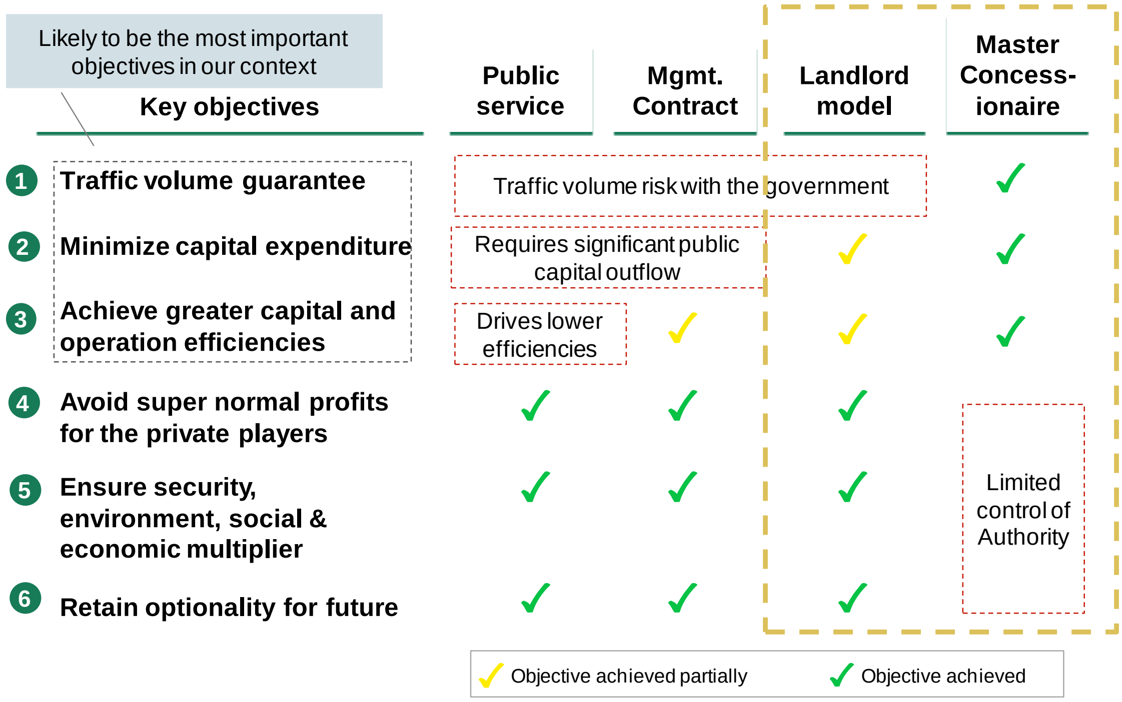


Figure 152: Key objectives of government

Given, securing volume is a critical success factor for Enayam, Master Concessionaire model will be an attractive option as the project structure. Though, as described in the figure below, Green field projects typically have very high risks associated with them and thus often find it difficult to attract private players.

Investor considerations

Investors evaluate assets basis the risk / return profile and the total capital outflow required

Higher the capital outflow, greater is the sensitivity to risks

Risks evaluated on many dimensions
- Volume risks
- Price Risks
- Land acquisition risks
- Risks of delayed connectivity/ Infra development

Green field projects carry significant risks

	Green field	Mature Asset
Volume risk	High	Low
Pricing Risk	High	Low
Land Acquisition risk	High	Low
Logistic project risks	High	Low
Regulatory risks	High	Medium

Figure 153: Investor considerations

In order to attract private investors, it is important to mitigate the capital and volume risk associated with this greenfield project. The land lord model alleviates the capital risk, land acquisition and risks of delayed connectivity, since the port infrastructure and connectivity is developed by the authority and the terminal operators invest only in the terminal infrastructure including equipment. Thus, this could be the alternate option in case the authorities are unable to attract interest from private players upfront. The two options have been further detailed out in the following sections.

14.3. MASTER CONCESSIONAIRE WITH A MINIMUM VOLUME COMMITMENT

The public authority should aim to get a master concessionaire upfront with a minimum volume guarantee. This will also help achieve capital deployment and execution efficiency as well as efficiencies in port operations (yard management, evacuation etc.).

- Target liners or port operators that can partner with liners and thus offer volume commitment
- Prescribe the minimum volume guarantee conditions in the RFP
- VGF can be made as the bidding parameter with an upper ceiling prescribed
- The concession period for master concessionaire could be fixed as 30 years, with an option to extend the concession up to 90 years in two extensions of 30 years each

Given this is a Greenfield project with high perceived risks, the public authority will have to give firm assurance / commitment on the following, in order to attract target partners

- Firm assurance on feeder network availability (potentially through Cabotage law relaxation)
- Timely completion of connectivity projects with some financial compensation in case of delays
- Financial incentives in order to bring equity IRR to 16% -18% (potentially as VGF)
- Assurance on potential tax/ duty exemptions, required for setting competitive tariffs

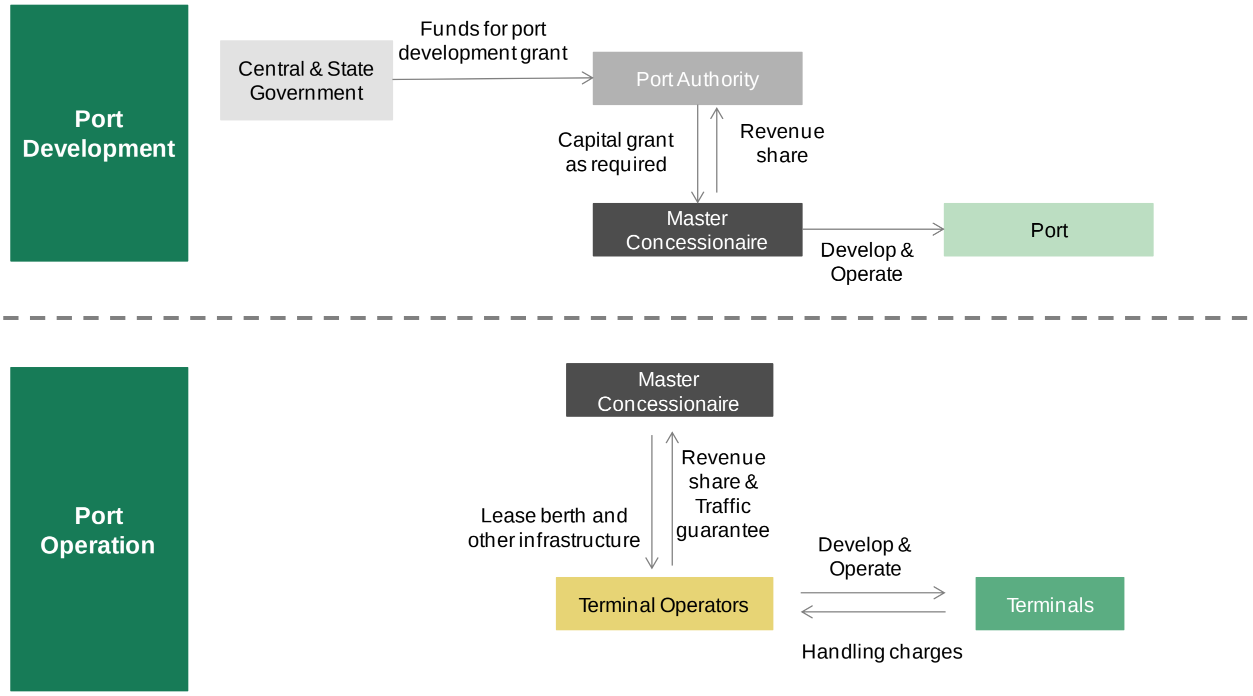


Figure 154: Master Concessionaire Model

It is advisable that the authority engages with a few operators and main liners to understand their risk appetite and willingness to invest at the development stage. In case, the interest is not high despite the above mentioned assurances, the government can consider Landlord model as described below.

14.4. LANDLORD MODEL AND PRIVATE TERMINAL CONCESSIONS

In case it appears difficult to attract target investors with volume commitment upfront, the government may have to develop the port themselves to reduce the perception of risk. The authorities should engage with liners and try to get MoU / firm assurances of investment in the terminal if and when the port is developed.

Further, to achieve capital and execution efficiencies, an EPC and maintenance contract for development should be considered. The authority should also offer a first right of refusal on terminal 1 concession to the bidder for EPC contract. This may help attract consortiums with participation of leading port operator / shipping liner companies. This will then ensure that the expert inputs from the port operators / liners are available and incorporated in the development phase. Also, the authorities will be able to get the operators / liners involved upfront in the project.

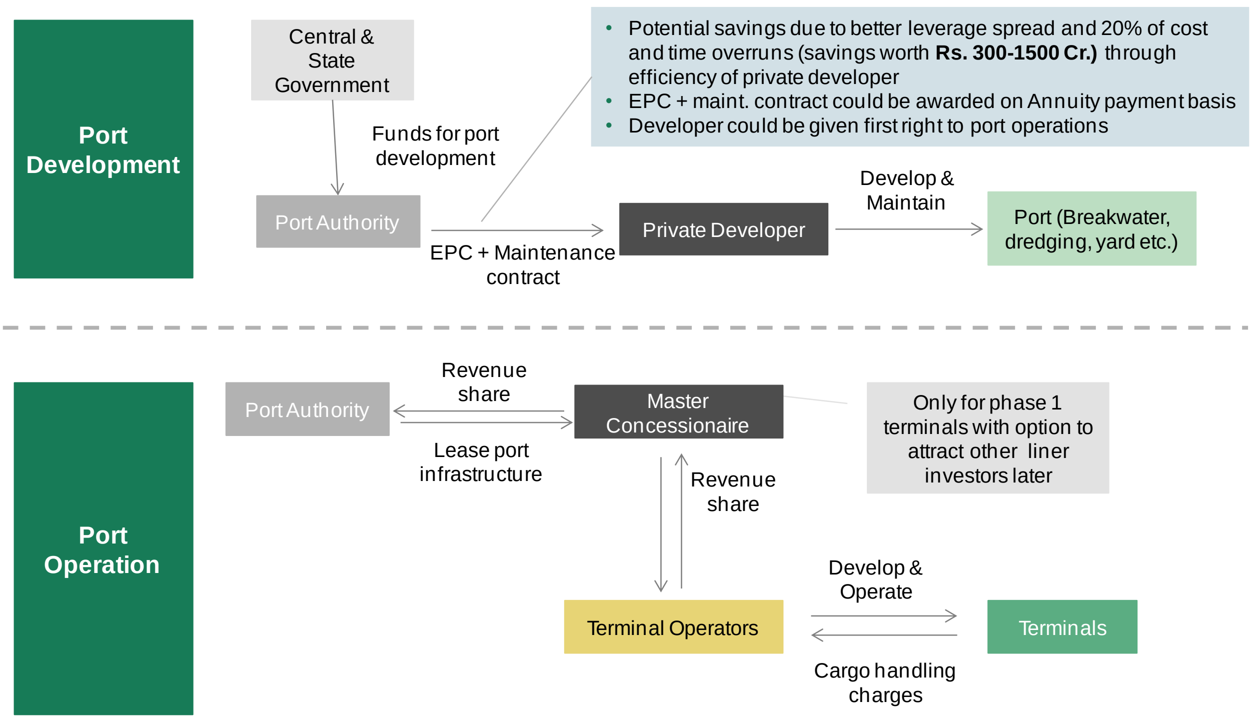


Figure 155: Landlord Model

14.5. FEASIBILITY OF COLACHEL AS A SATELLITE PORT TO VOCPT

Colachel Port can either be, developed and implemented by VOCPT as a satellite port, or by a new authority as an independent port. It is advisable to implement Colachel Port project as an independent port under a new public authority, in order to mitigate risk of conflict of interest and achieve global productivity levels as a greenfield port. If VOCPT considers it suitable they may invest equity in the new port authority, along with Ministry and State Government.

15. IMPLEMENTATION PLAN

15.1. INTRODUCTION

It is well known that the Authorities intend to carry out works proposed in this document in such a way that the terminal should be fully operational by 2018. Besides, the beginning of operations with only one berth should occur before August 2018 as an intermediate milestone.

The estimated budget for carrying out these works is approximately 5,500 crores. This is an important amount of money entailing a large volume of work that has to be carried out within a very tight time scale.

Thus, companies selected to build the terminal and to carry out the breakwater works must understand and assume that this is a major challenge, and must be capable to accomplish it. These works require detailed planning, considerable technical competence, major human resources and high-performance machinery so that different work units can be deployed almost simultaneously, thereby reducing any possible overlapping.

15.2. DESIGN AND TENDER

Before the beginning of works takes place, the design documents have to be prepared, the environmental impact process has to be approved by the competent authority and the tender for the concession of the terminal has to be drawn up.

Within the design process to be done, the following surveys and studies should be included:

- Field surveys: A bathymetric and geophysical survey, including side scan sonar and a sub-bottom profiler should be made on an area large enough to include all expected phases and approach channel. It should be completed by a geotechnical survey including boreholes, laboratory tests and soil sampling. Besides, a detailed topographic survey should be carried out at the port area and at the related connectivity corridors.
- Models and studies: Numerical models should be developed on ship manoeuvring, sediment transportation and wave tranquillity (updating and upgrading the study included in this report). Also, scale models could be done to assess and optimize the design.
- Engineering works: This should include an optimization on breakwaters design and basic design on berth structures, pavements, foundations, buildings, networks and utilities. Regarding connectivity, a deeper study on the proposed railway and road linkages should be done, including optimization of alignments, traffic study, and design of drainage, structures, pavements, signalling, etc.
- Environmental and social impact assessment: A Comprehensive EsIA Report and a Land Acquisition Report should be developed in order to identify the impacts on private and public properties of the project.

A 6 month period for both the design and tender process is expected, although some overlap can be expected too.

15.3. CONSTRUCTION SCHEDULE

The construction works will begin by setting up the site installations, determining where the offices should be placed and where machinery and materials should be stored (e.g. concrete breakwater armour units, rip-rap, reinforcing bars etc.). This zone should make it possible for the different work units to carry out their work reducing distance for transportation and increasing machinery performance. The timeline presented here implies dividing the building work into four parts:

- Maritime works (26 months): Breakwaters, rubble mound and berths.

  The first task is the breakwater works (18 months): this begins by building the main rubble mound breakwater that runs for the first 1,300 m and is then vertical for another 2,500 m. During this period, the rubble mound breakwater to protect the landfill at the south-eastern part of the terminal will also be carried out.

  Both the main breakwater and the east breakwater will be carried out in advance using land-based and maritime means. The vertical breakwater comprises reinforced concrete caissons that will be built by maritime means (a floating shipyard for caissons) in a zone that has a sufficient draught or in a prepared land area. Then, they will be floated to where they are to be put in place. Before they are anchored, the area will be prepared by creating the rip-rap and the gravel bedding layers. Once they have been submerged, the cells are filled with granular material and the crowning slab is put in place. The breakwater work ends with the creation of the protective breakwater crown wall.

  The dredging work begins by digging the trench for the bedding layer of the vertical breakwater. As soon as the mound breakwater has been built and provides sufficient protection, work should begin on the inner basin (multi-purpose and ancillary berths) up to level 15.00 and subsequently the outer basin up to level 20.00. The material that is dredged up should be pumped into the zone where the future terminal is to be situated, so that it can be used as landfill.

  The dredging work can be affected by the monsoon season which falls between the months of May to September. During this period, the south west swell implies higher waves, which in turn means a reduction in the performance of the dredging equipment. It is estimated that the dredging works should take around 17 months.

  In much the same way, the piers (container, multi-purpose and ancillary berths) shall begin to be built as the breakwater progresses. There is a 16-month deadline. This work shall be carried out using maritime means (pontoons or jack-up barges), and land-based means once the rubble mound bunds have been created. The piles will be put in place first, then the sloping rip-rap protection and finally the reinforced concrete superstructure (beams and slabs).

- Land works (16 months): Yards, networks, utilities and buildings.

  Work on the terminal will be carried out during this phase, beginning with the work to consolidate the landfill and the creation of the walkway on which paving blocks will be laid. These tasks will take 12 months.

  Thereafter, work will be carried out on the terminal access facilities (gates), on the internal railway (8 months) and also on the installations that serve the terminal and the docks (electricity, lighting and water supply, fire fighting elements, bunkering, sewage and communications).

  It is estimated that it will take 10 months to construct the buildings (port management buildings and operation and maintenance buildings). They will be built in parallel to the aforementioned tasks.

- Equipment (7 months): STS Cranes (quay), A-RMG Cranes (yard), RMG Cranes (rail yard) and others.

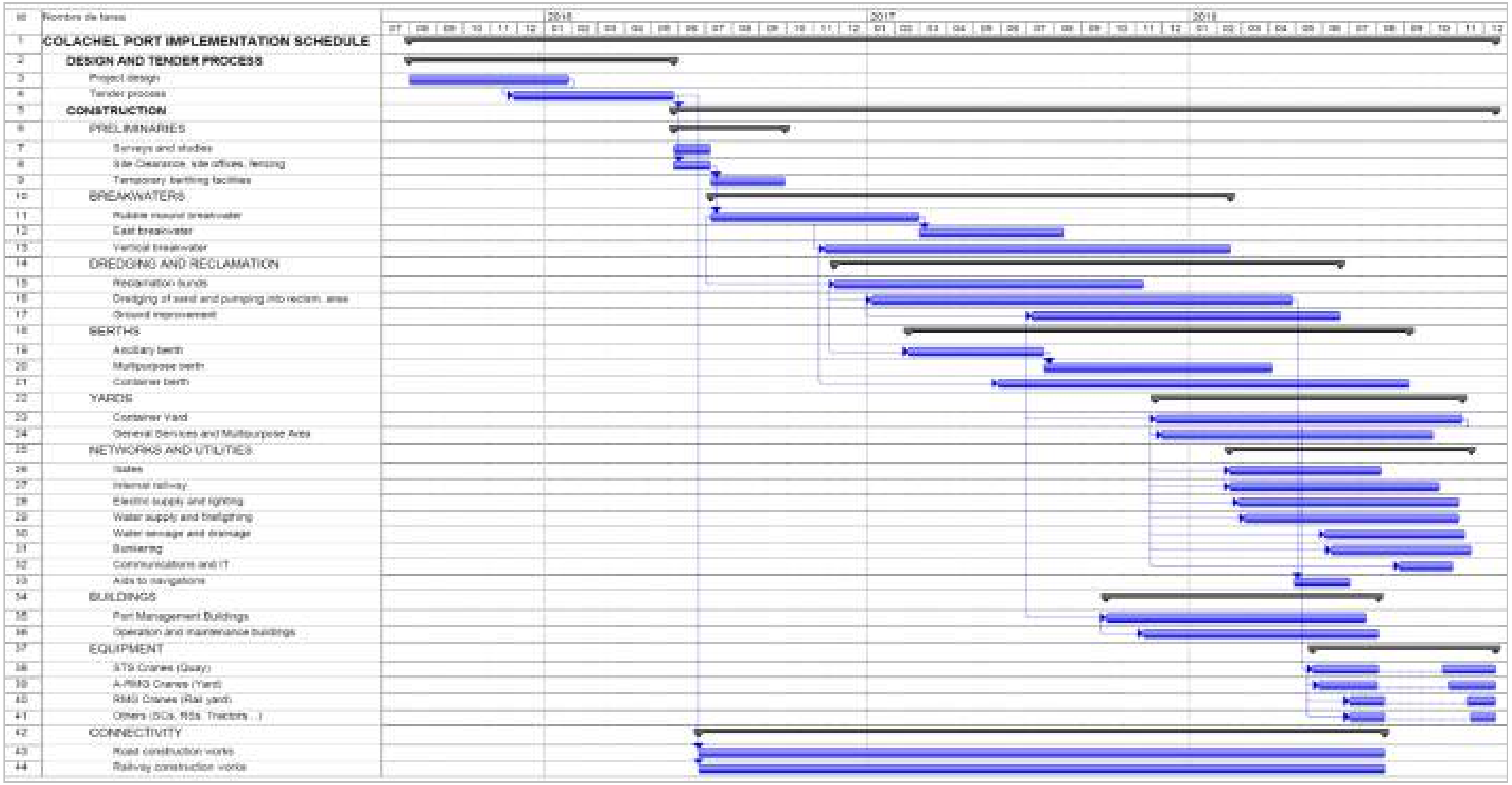
  The operating equipment for the berthing line and for the yard will be purchased and installed gradually, as the berthing line and the container yard becomes operational. As stated above, the first container berth should be operational on August 2018. This means around half the container handling equipment must be operational by this date.

- Connectivity (25 months): Road and railway construction works

  The road and railway providing access to the terminal will constructed continuously throughout the 25 months that it takes to carry out the works. They should be operational on August 2018 to allow gateway traffic entering and leaving the port easily.

The schedule included in next page shows the times and relations of each task and subtasks explained above.

Although the design of Phase 2 and 3 follows the forecasted traffic the construction of facilities for these Phases should be carried out when the existing ones are near congestion so that the productivity and profitability of the port can be optimized.


COLACHEL PORT IMPLEMENTATION SCHEDULE
DESIGN AND TENDER PROCESS
Project design
Tender process
CONSTRUCTION
PRELIMINARIES
Surveys and studies
Temporary berthing facilities
BREAKWATERS
East breakwater
Vertical breakwater
DREDGING AND RECLAMATION
Ground improvement
BERTHS
Ancillary berth
Multipurpose berth
Container berth
YARDS
Container Yard
NETWORKS AND UTILITIES
Internal railway
Electric supply and lighting
Water supply and firefighting
Water sewage and drainage
Bunkering
Communications and IT
Aids to navigations
BUILDINGS
Port Management Buildings
Operation and maintenance buildings
EQUIPMENT
STS Cranes (Quay)
A-RMG Cranes (Yard)
RMG Cranes (Rail yard)
CONNECTIVITY
Road construction works
Railway construction works
2016
2017
2018

16. MANAGEMENT AND SUPERVISION DURING CONSTRUCTION

As mentioned above, the execution of the works described in this report in such a short time requires a great effort on planning and monitoring of works, as well as great technical expertise not only by the contractor, but also by the project management and supervision consultancy.

The proposed team to carry out Project Management is divided as follows:

- Project Manager: This position will coordinate the construction works and will deal not only with the contractor and supervision, but also with the Authorities involved in the project (Ministries, TNMB, Collectorate, Municipalities…).
- Project Management Staff: A group of specialists will be supporting the Project Manager on his duties. Contracts, planning, costs and quality control specialists will be required, as well as a document controller and other support and administration staff.

Regarding Supervision of works, the proposed team is divided in three sections for each of the suggested construction contracts; Marine works, land works and rail & road works. The three teams will be leaded by resident engineers, who will share a group of technical senior advisors on each main engineering field: The

- Marine works: In addition to the resident engineer, four assistant engineers (dredging, reclamation, breakwaters and quay works) will be included. Some other technical staff (QA/QC and HSE superintendents, land and marine surveyors and site inspectors) and other support staff will form part of the team.
- Land works: This team follows the same structure. Again, four assistant engineers will be needed (pavements, utilities, buildings and networks), supported by technical and administration staff.
- Connectivity works (Rail and Road). Earthworks, pavements, structures, tracks and networks & utilities assistant engineers will form part of this team.
- Technical senior advisors: A group of high degree of expertise engineers and specialists will be helping the supervision teams on any technical decision or issue. This team will guarantee all decisions are made with the required level of analysis.

Figure 156 shows the organization of the Management and Supervision team:

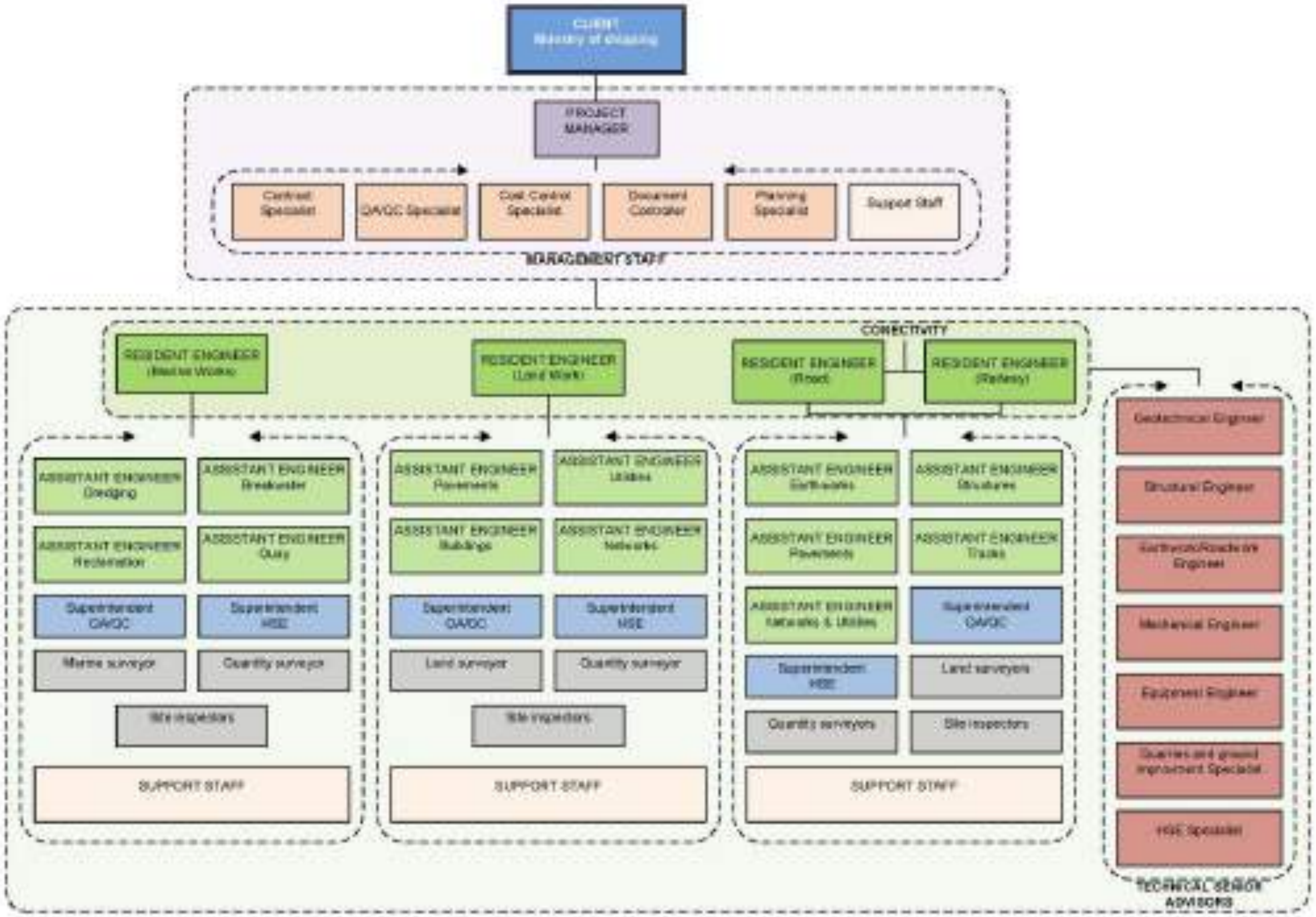


Figure 156: Management and supervision staff chart

17. RISK ANALYSIS

17.1. LEGAL AND CONTRACTUAL RISKS

Types of risk	Risk description and mitigation
Risk of disputes	With private sector participation in project development and operation, conflicts may arise between private players and government. The concession agreement should be balanced and a robust dispute resolution mechanism should be incorporated
Change in law	An unexpected change in current legal / regulatory / policy regime in port sector can have a material adverse impact on the project. Any policy formulation should keep this in mind and the contractual arrangement should suitably address this possibility.
Delays in project development	▪ The Project contracts should provide for significant penalties for such delay ▪ Public authority may assist the developer in obtaining consents and clearances from governmental agencies.
Funding risk	▪ The port development is dependent of availability of funds. It is vital that the project and contractual arrangement be structured to make the project attractive to banks and equity investors. ▪ Depending on the project development option, funding risk has to be borne by the private player.
Project completion risk	▪ Concession Agreement should address the issues related to Concessionaire's default in this case. ▪ Strict project monitoring by the Authority/Independent Consultant is required. ▪ EPC contracts for mandatory works may be structured as a fixed-price and fixed-schedule contract, with stiff liquidated damages for non-compliance. Performance guarantees may also be stipulated. ▪ Insurance package involving Contractors All Risk, Third Party Liability, and Advance Loss of Profit may be taken during the construction period
Delay in land acquisition	As this is a green field project, land acquisition would be required for connectivity and other surrounding industries. Public authority being the owner should take responsibility for acquiring land for project development.
Interest rate risk	These are factors affecting the availability and cost of funds. To mitigate this risk, hedging instruments or fixed rate loans to be used.

Inflation risk	The possibility that the actual inflation rate will exceed the projected inflation rate. This risk is to be borne by the infrastructure developer, whether government or private player.

Table 59: Legal and contractual risks

17.2. REVENUE RISKS

Types of risk	Risk description and mitigation
Risk of traffic volumes	Traffic volumes projected for the port (which forms the basis of capacity planning of the port) is subjective to Enayam port being competitive to major trans-shipment hubs on key metrics like productivity, availability of feeder network etc. It is necessary that all the key imperatives as mentioned in the Key Success Factor chapter are implemented on ground
Risk of cost pressure on tariffs	Tariff structure of Enayam would need to be competitive with major trans-shipment hubs. Any escalation of costs due to increase in labour rates etc. can make it difficult to maintain competitive tariffs. Strong cost control mechanisms including efficient manning, procurement etc. should be put in place from the onset.
Risk of price war	Competing trans-shipment hubs in the region may .respond in price war once they start losing traffic to Enayam. Enayam should focus on getting into long term contracts with shipping operators and try to attract investments from them .
Risk of new competitor taking share of traffic	New competing port in the region may take away part of Colachel's share. For Indian competitors, GoI must measure impact on Colachel's traffic before commissioning new container hub in the region.

Table 60: Revenue risks

17.3. TECHNICAL AND ENVIRONMENTAL RISKS

Types of risk	Risk description and mitigation
Risk of flood	Tamil Nadu is a high rainfall region that experiences localised flooding due to heavy rainfall especially during the SW monsoon, resulting damage to life and property. The Colachel district comes in high risk zone. Since a number villages in the district are *flood affected areas*. The project can be affected by flash floods, which occurs on the coast when high intensity rainfalls in a localised area happens over a short period of time, in

	combination with high and spring tide. Most of the flooding problem in the area is due to poor or choked drainage conditions. Some measures to avoid this risk are conducting a flood route analysis, installation of water pumping stations, Installation of warning systems (alarm, audio-visual public address system, etc.) and coordination with State and district level disaster management authorities.
Risk of cyclone or wind storm	Tamil Nadu is also vulnerable to cyclones and experiences high winds due to the westward movement of the cyclonic storms crossing the State coast. A great part of the State falls in high wind speed areas and the Colachel district falls under medium level risk zone. Measures to reduce risk are designing port facilities such as buildings, transmission systems, storage, etc. Taking this risk into account. Coordination with State and district level disaster management authorities will be useful too.
Coastal Hazards	Coastal Hazards such as erosion, storm surge, tidal waves, swell waves, etc.; have the potential to harm the people, property and the environment. Erosion control structures in critical areas, shoreline protection walls and coordination with other authorities are measures to be taken.
Tsunami	The Tsunami was one of the most devastating disasters in modern history. In 2004, Indian Ocean Tsunami struck the 11 countries and killing more than 225,000 people. In Colachel the tsunami waves hit the District, which resulting in the death of a large number of persons and damaged houses. Safety measures in accordance with mathematical study of Tsunami waves height, tsunami warning systems and coordination are measures to reduce this risk.
Ship mishaps and vessel accidents	During towing and berthing of the ships, owing to natural calamity or piloting errors, there can be remote possibility of mishap of one to one ship collusion or ship hitting against the wharf or ship getting grounded. During such events, the ship may sink or break. Direct control and management of the movement, position, timing and manner in which a vessel may enter and leave the port waters, maintenance of safe and navigable channels and coordination of vessel movements are the best measures to reduce this risk.
Oil Spillage	The risk of accidental spillage of oil from ship and cargo handling pose a threat to marine and land based resources. This requires careful and

	advance planning to ensure that the impact of the oil spill on environment is minimised or contained. Proactive measures such as display of zero tolerance information boards for all kinds of pollution in all important areas of Operation is expected to lead to extra care with regards to pollution.
Fire/explosion	There is risk of fire or explosion due to the electrical fault, handling, transportation and use of petrochemical and flammable products. Recommendations that may be implemented are installation of Audio-Visual public address system to alert the personnel working in the terminal, smoke or fire detectors will be placed at critical locations in the terminal, fire alarm systems, periodic inspection and maintenance and adequate measures in the safety system design, Personal Protective Equipment (PPE) such as masks, respirators etc. may be provided to the workers.
Hazardous Material handling	Hazardous materials have adverse effect on public health and safety as well as environment due to the release or leakage of hazardous materials. Hazardous materials that may be stored, transported and handled within the Port area are classified by the following: (Hazardous Waste Management handling rules 1998 (amended)

18. CONCLUSION

This rapid techno-economic feasibility report discusses five key aspects of the port: 1) technical feasibility, 2) traffic potential, 3) financial viability, 4) key imperatives for the success of the port and 5) the way forward.

Technical feasibility

After studying and comparing four locations, Enayam has been chosen as the most suitable location. Further, detailed port layout, design and cost estimation for Phase 1 of the port has been undertaken to assess the technical feasibility of the port. From the technical point of view, the port is highly feasible due to the site conditions and the proposed design. These characteristics are listed below:

a) Site conditions:

- Enough natural depth. This helps the port to have high draft ad to be designed without long approach channels.
- Proximity to main shipping routes.
- Low population on the vicinity of the port. This allows the port to be well connected to main transport networks, and industries to be settled near the port.
- Enough available shoreline to expand the port easily.
- Geotechnical conditions are expected to be favourable, being the soil easy to dredge and with enough bearing capacity for foundations.

b) Design conditions

- Terminals have been designed with a high productivity in a semi-automated operation mode. Productivity can reach 2,000 TEU per meter and per year.
- Permeability between port and land is very high.
- The port layout gives very low downtime for container berths (less than 2 days per year).
- Taking advantage of available shoreline, an expandable port has been designed, with an approx. construction cost of Rs. 19,300 Crores for 3 phases. Eastward expansions can quadruplicate the container handling capacity, reaching 8 million TEUs per year if all shoreline is used.
- Further, this capacity can be expanded to 16 million TEUs by expanding the port seawards and taking advantage of the vertical breakwater to use it as a berth line.

Traffic Potential

A comprehensive traffic and market study was conducted to determine the traffic potential of the port. It has been estimated that the port has a potential of 6.8 Mn TEUs container traffic (2.9 Mn TEUs gateway and 3.9 Mn TEUs trans-shipment) and 6.6 Mn Tonnes of Coal traffic in 2030.

Financial Viability

The financial viability of the project has been assessed by developing a discounted cash flow model using the capital cost inputs from technical study, revenue stream from traffic and operating cost based on port benchmarks. The tariff structure has been evolved to make the port competitive with Colombo Port. With a project IRR of 10.8% and equity IRR 11%, it has been estimated that the project would require capital support from the government in the form of 20-30% viability gap funding to make the project financial feasible at a target equity IRR of 16-18%.

Key Imperatives for the success of the port

Discussions with all leading shipping liners, leading Indian and International port operators have been conducted and other major container ports in the world have been studied to understand the 'key imperatives' for Enayam. While, these key success factors have been analysed with the view of establishing a large competitive trans-shipment port, the same factors are also applicable for attracting gateway container traffic.

Basis these discussions, the following imperatives have been identified for ensuring success:

1. Deep draft
2. Proximity to main shipping routes
3. Scale of capacity and sufficient gateway traffic
4. Sufficient feeder capacity and cost efficient network
5. Competitive port related logistics cost
6. Efficient customs approval process
7. Hinterland road and rail connectivity
8. Cheap bunkering services

The location and design of Enayam already meet the requirement of deep draft, proximity to main shipping routes, sufficient scale of capacity and potential of gateway traffic. Government needs to take steps towards meeting the other key imperatives for the success of the project.

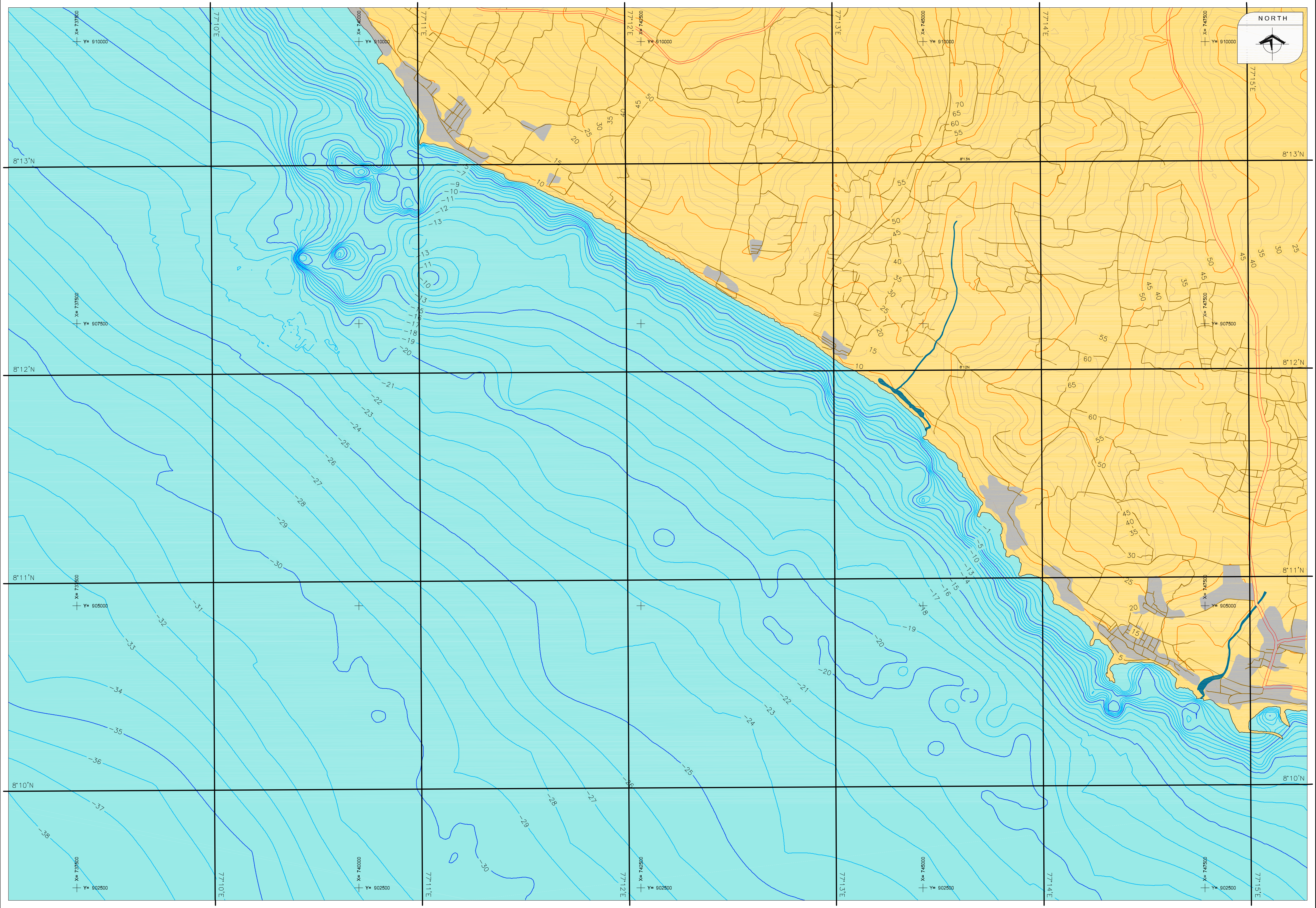
Way forward

In order to decide the way forward on project structure and investment plan, it is important to keep the key imperatives in mind. One of the key imperatives for project success will be to get the right partner on board. Securing a large liner as an anchor investor will be crucial in getting volumes and achieving critical scale of operations. Also, given the need to achieve high productivity, the port should be operated by an experienced and best in class port operator. At the same time, one of the other big objectives for Government will be to optimize financials and minimize capital cost for the project.

It is advisable that the authority engages with a few operators and main liner to understand their risk appetite and willingness to invest at the development stage. If they are willing, the master concessionaire model can be considered. In case, the interest is not high due to perception of high execution risks, the government can consider the landlord model.

19. DRAWINGS

CLIENT: V.O. CHIDAMBARANAR PORT TRUST	CONSULTANTS: TYPSA BCG	PROJECT: RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU	DATE: AUGUST 2015	SCALE: - ORIGINAL: A-1	DRAWING: LOCATION FILE NAME: CP1832-FR-PL-01-01-CP-Location-Ed2.dwg	DRAWING N°: 01 SHEET: 1 OF 3



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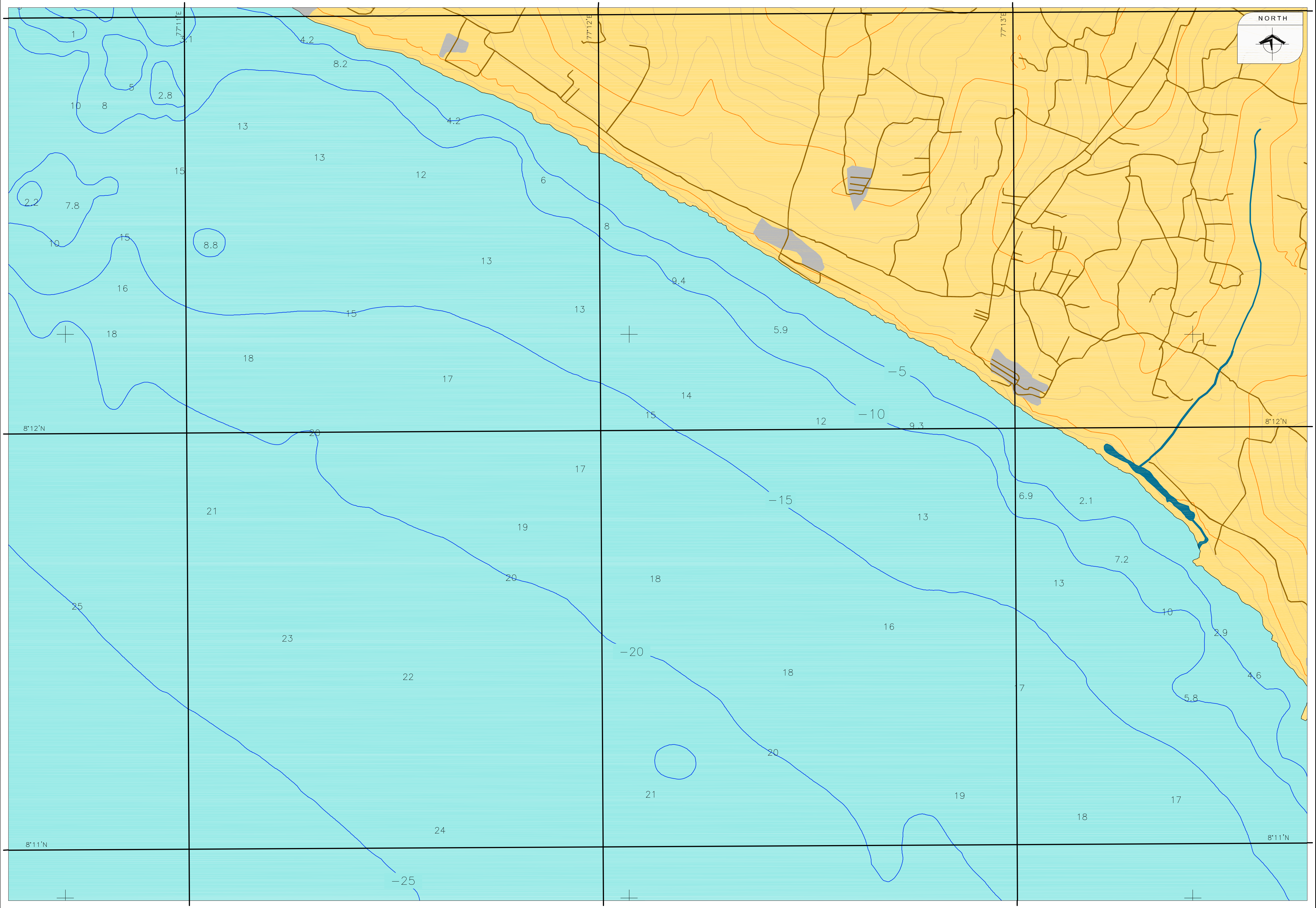

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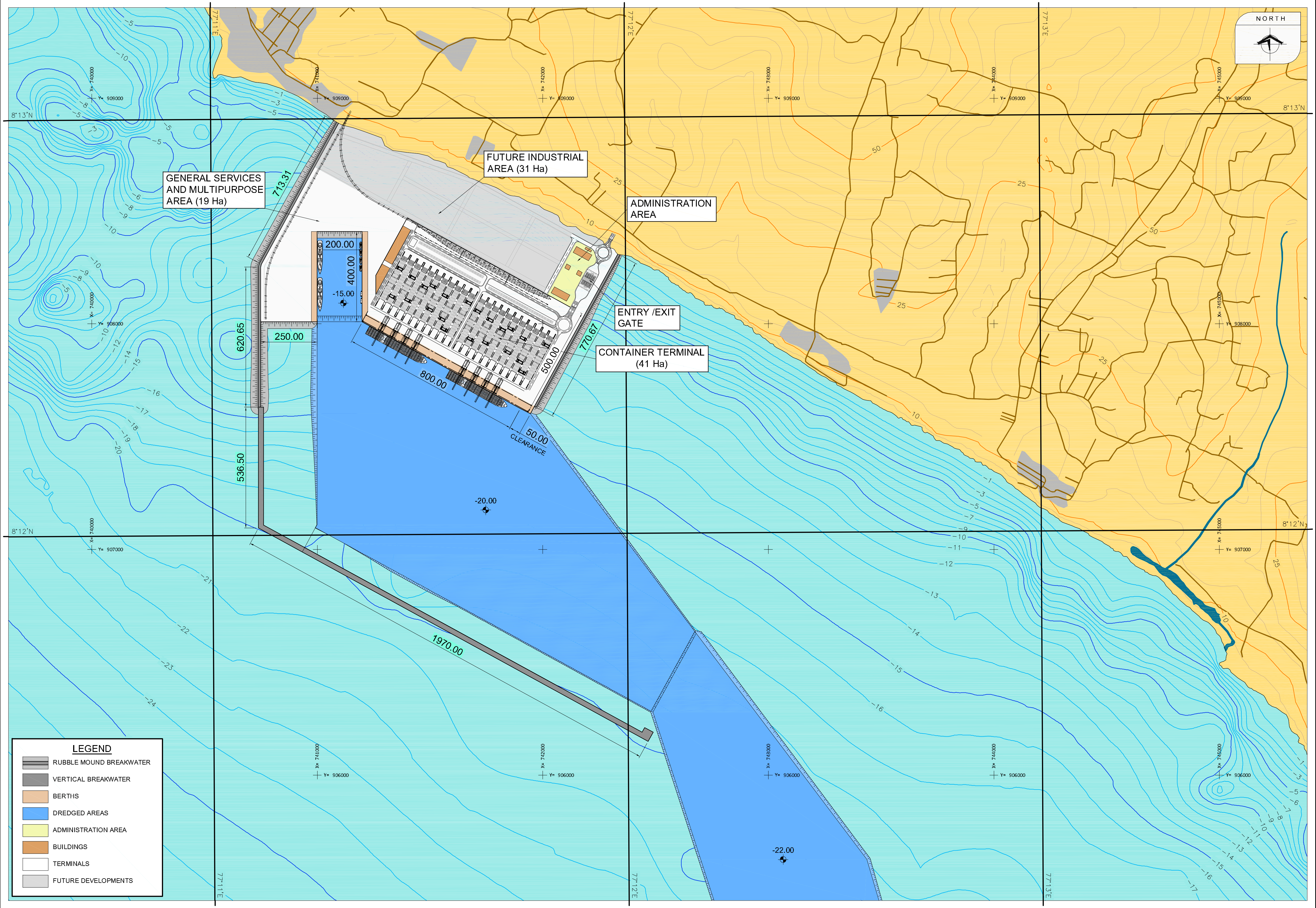

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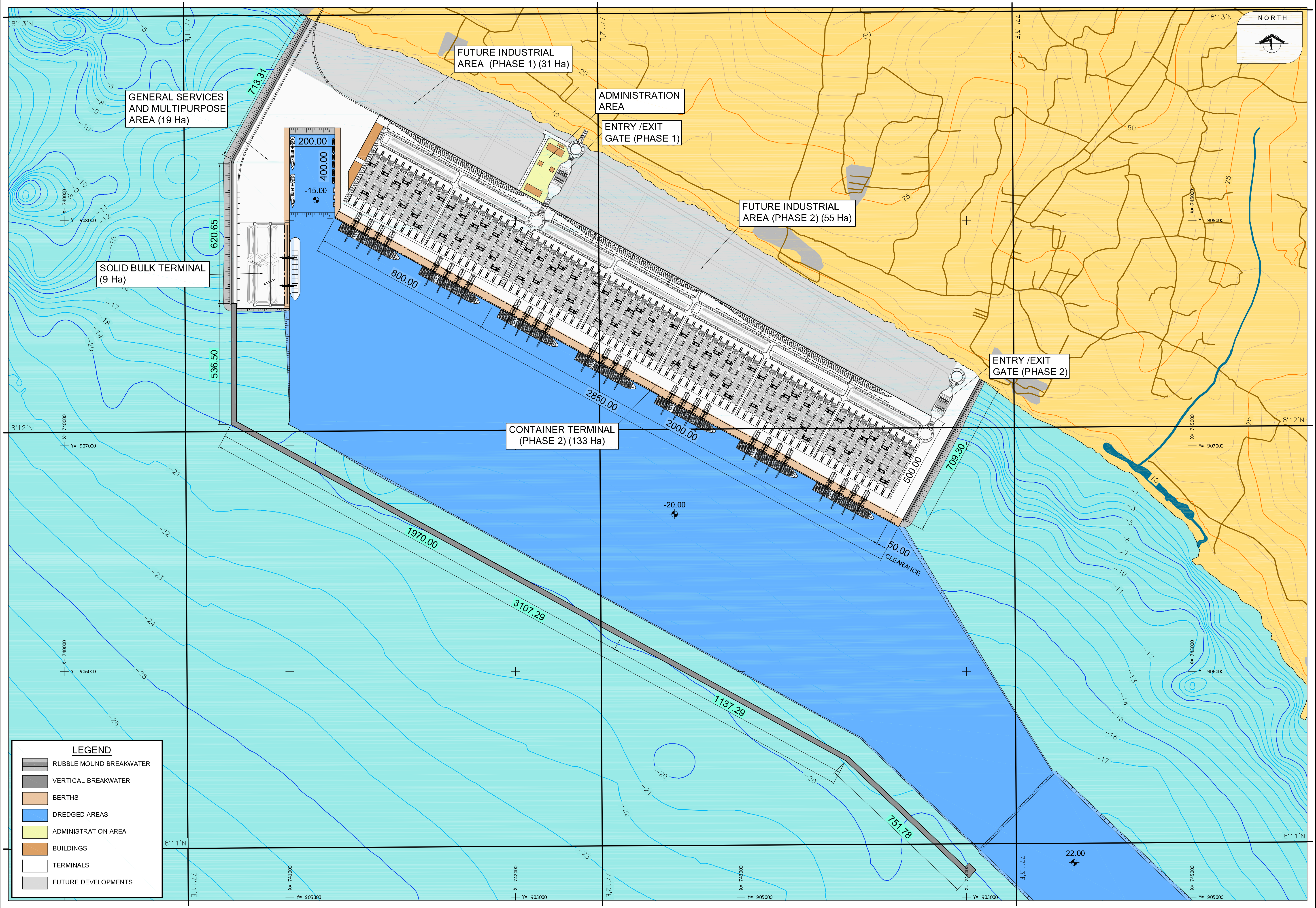

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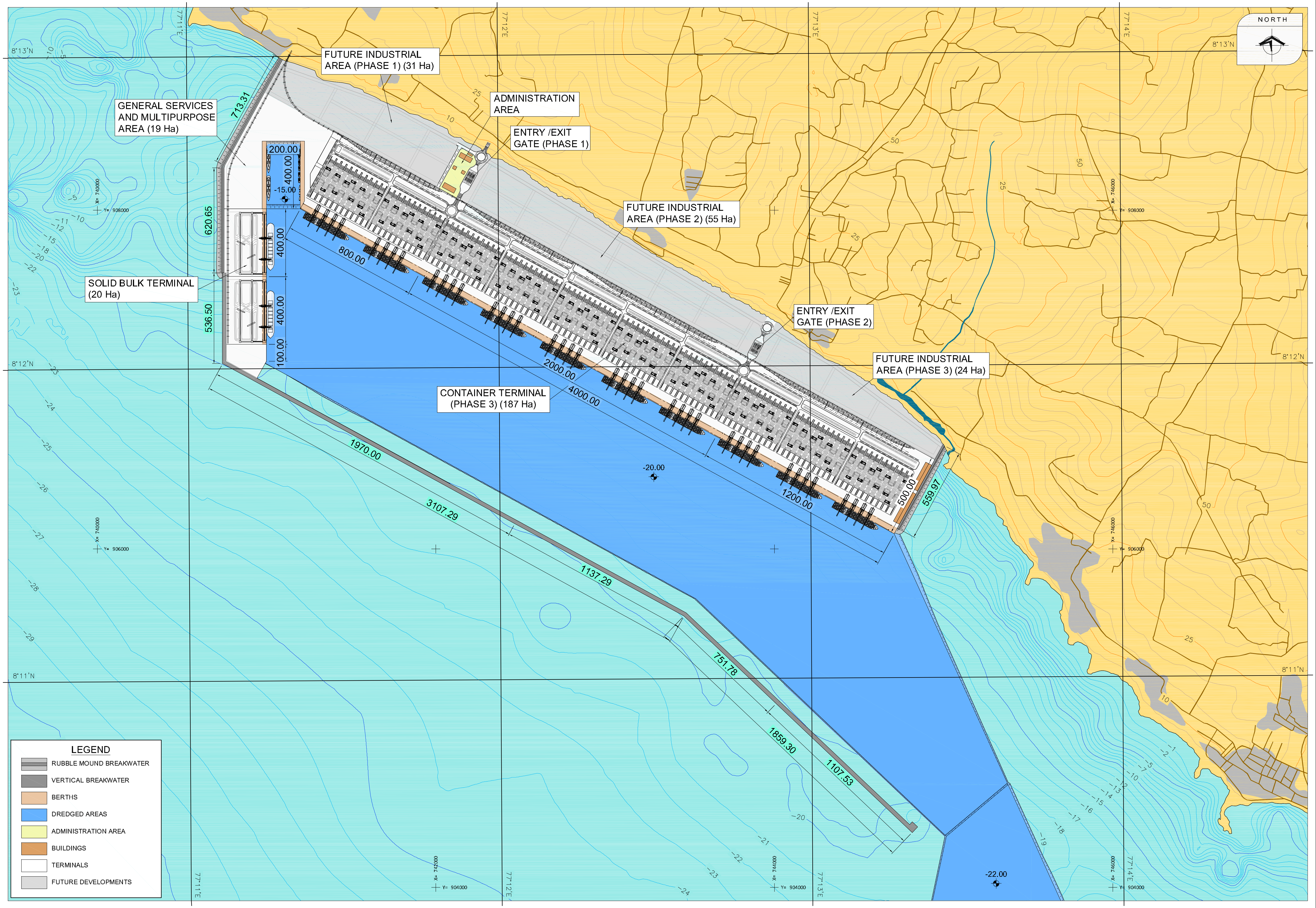

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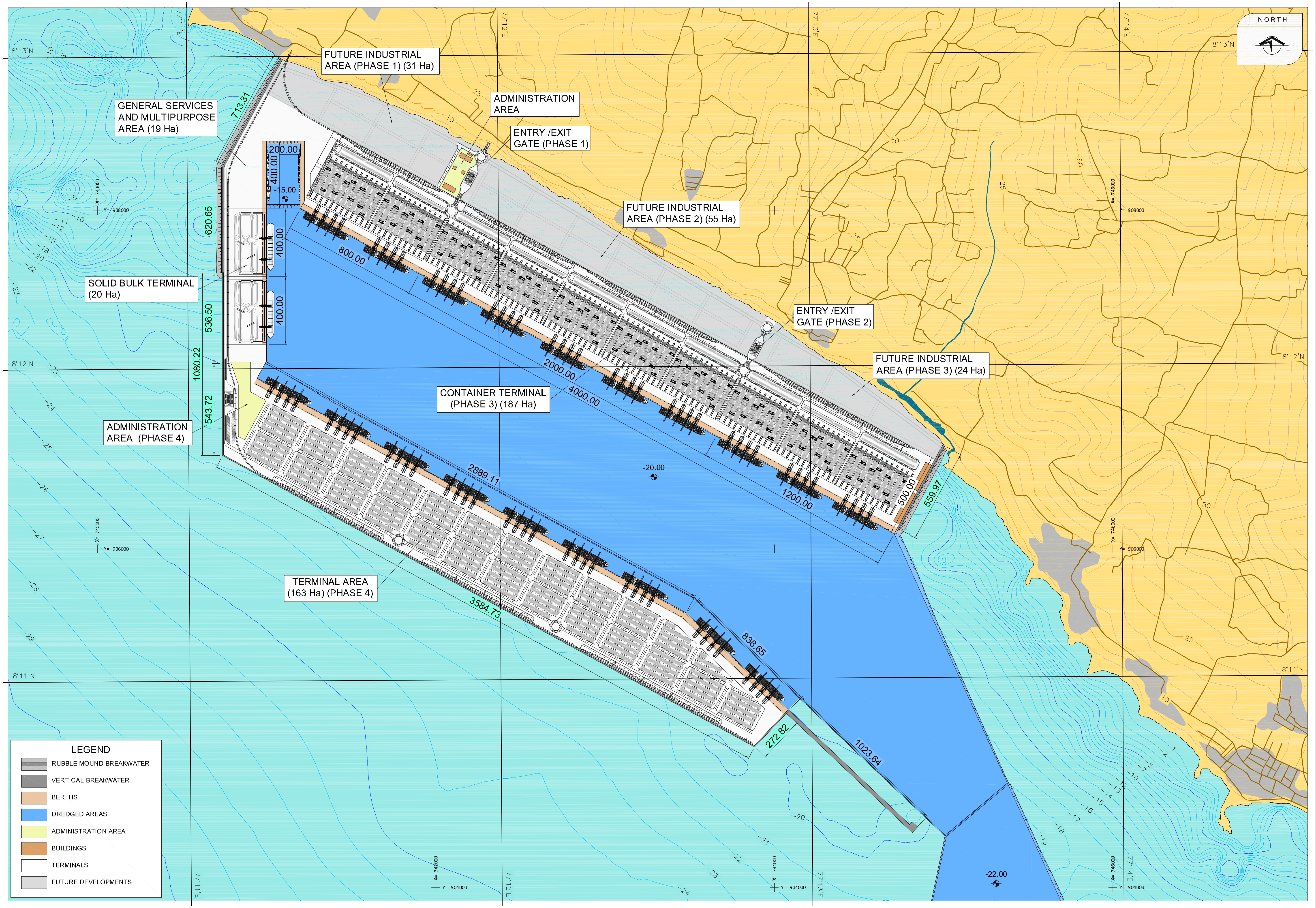

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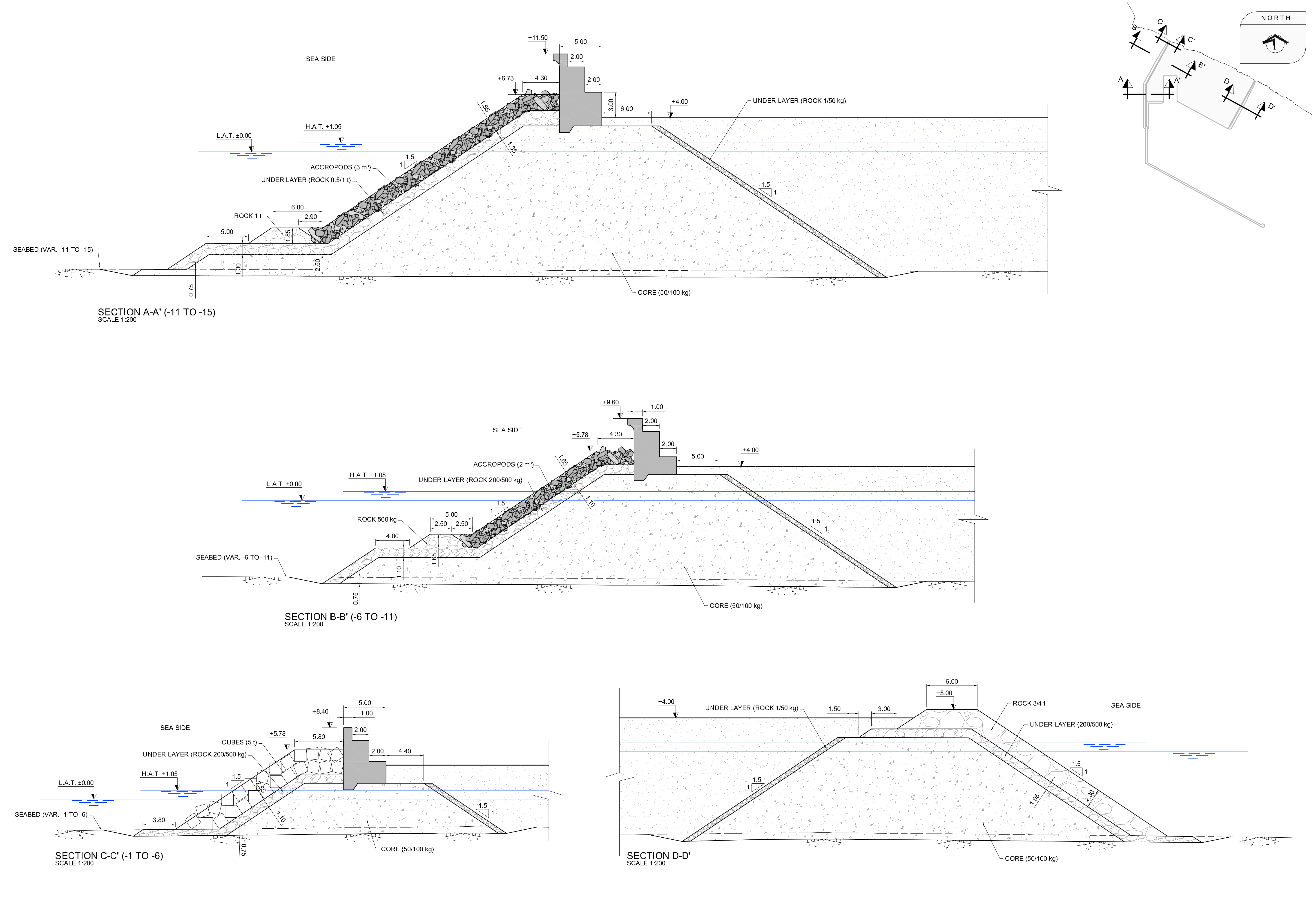

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V.O.CHIDAMBARANAR PORT TRUST

CONSULTANTS: TYPSA BCG

PROJECT: RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU

DATE: AUGUST 2015

SCALE: 1:200

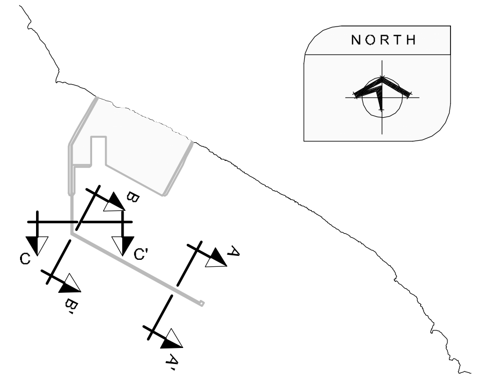
ORIGINAL: A-1

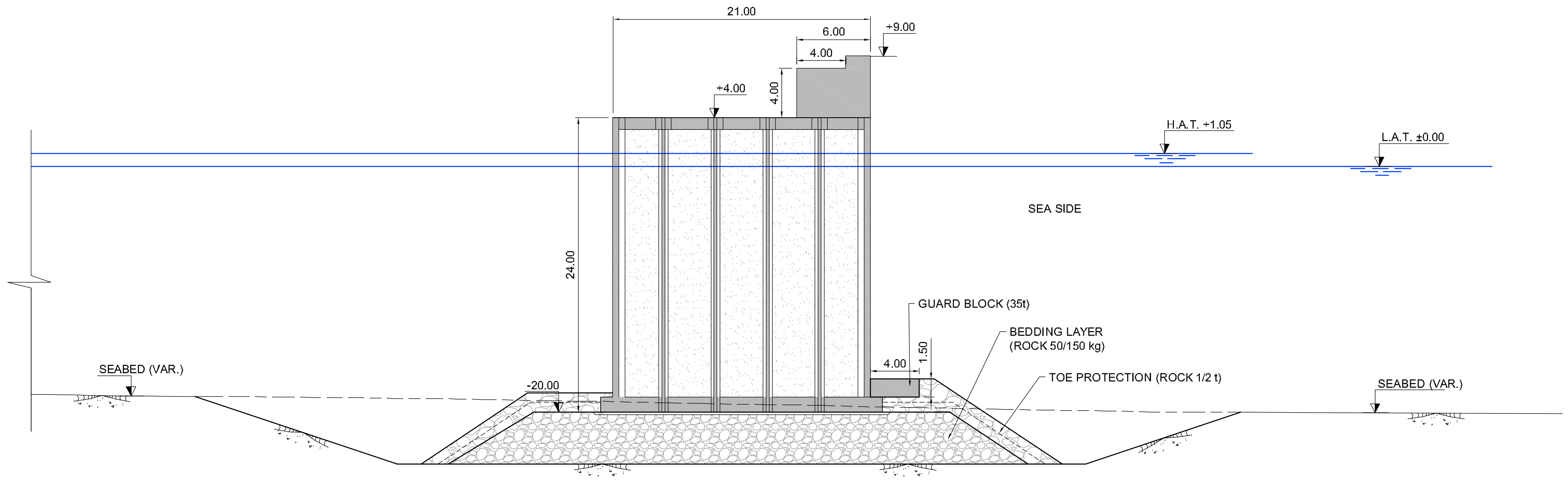
DRAWING: RUBBLE MOUND BREAKWATER. CROSS SECTIONS

DRAWING N°: 03

SHEET: 1 OF 1

FILE NAME: CP1832-FR-PL-03-01-CP-BreakwaterRM-Ed2.dwg





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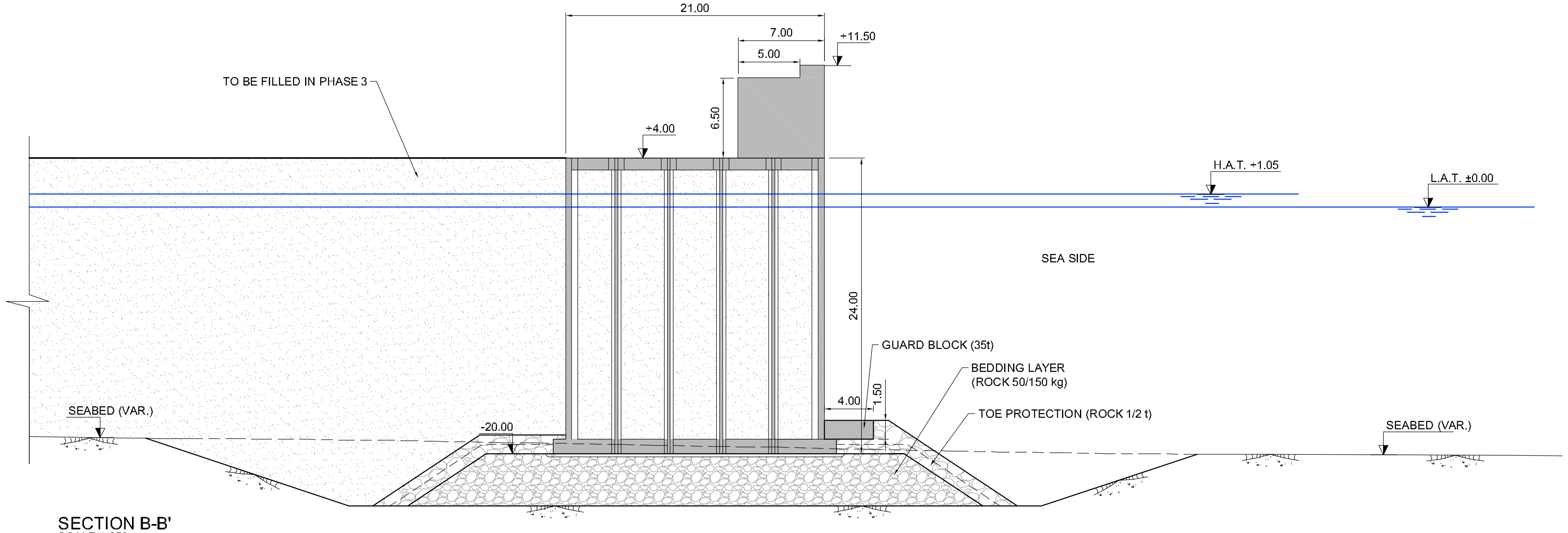
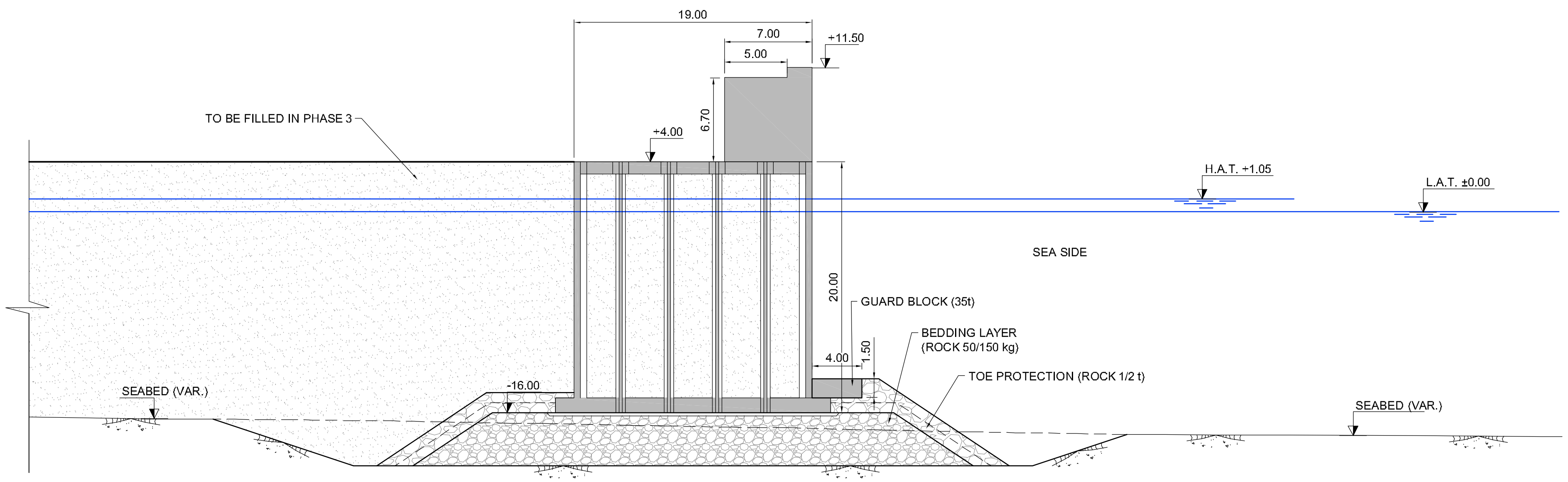
SCALE 1:250



SECTION B-B'
SCALE 1:250



SECTION C-C' (-15 TO -20)
SCALE 1:250

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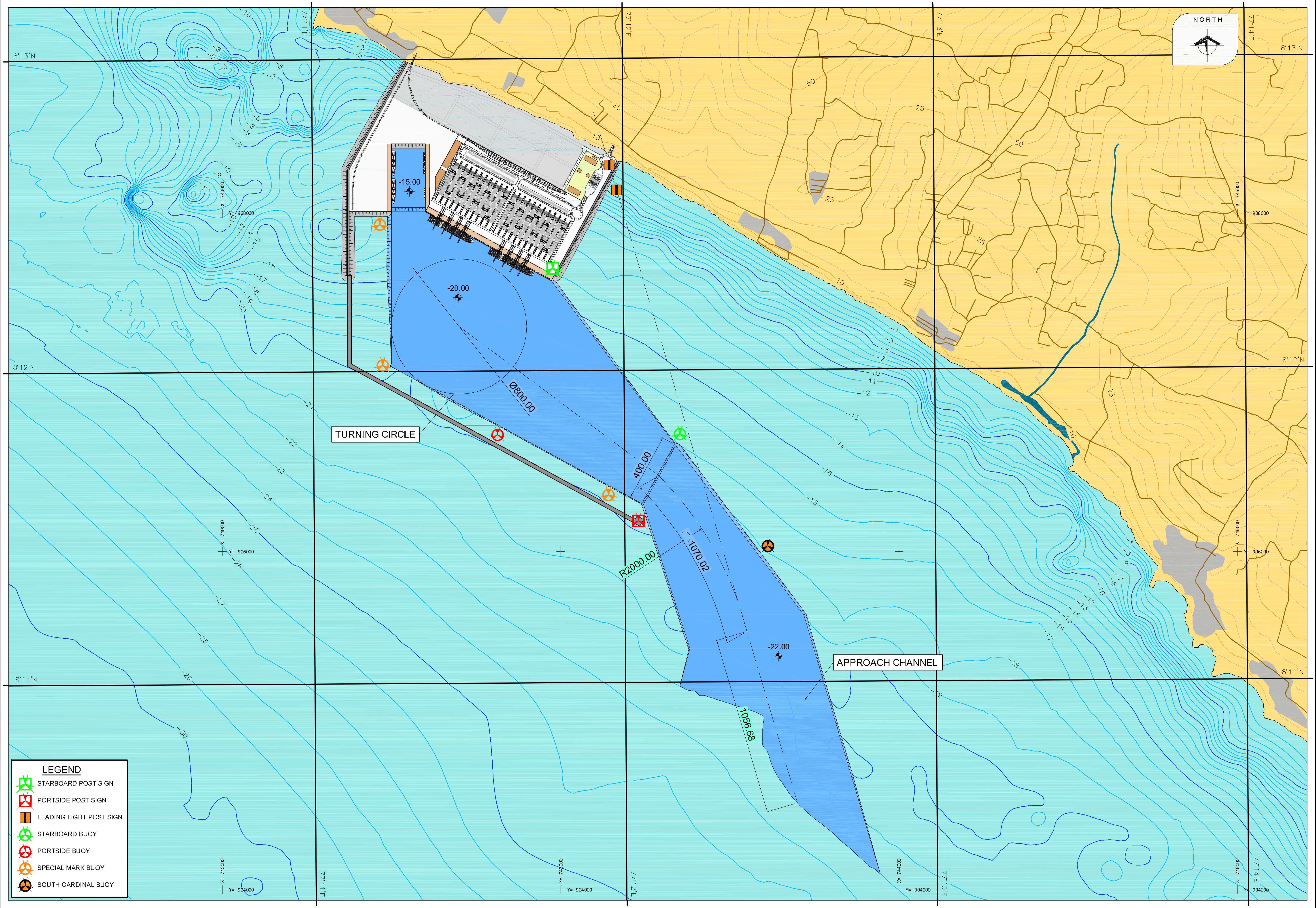

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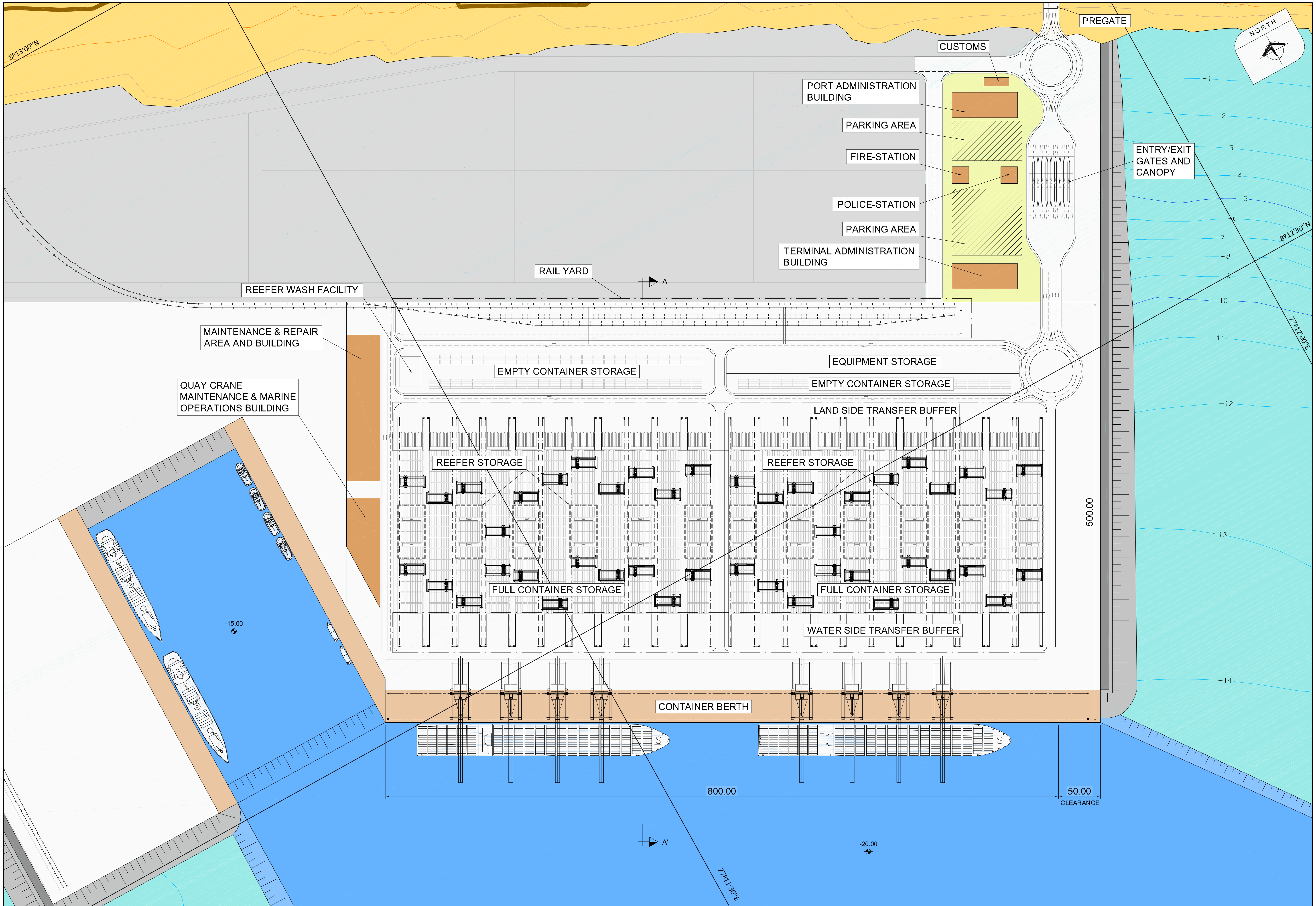

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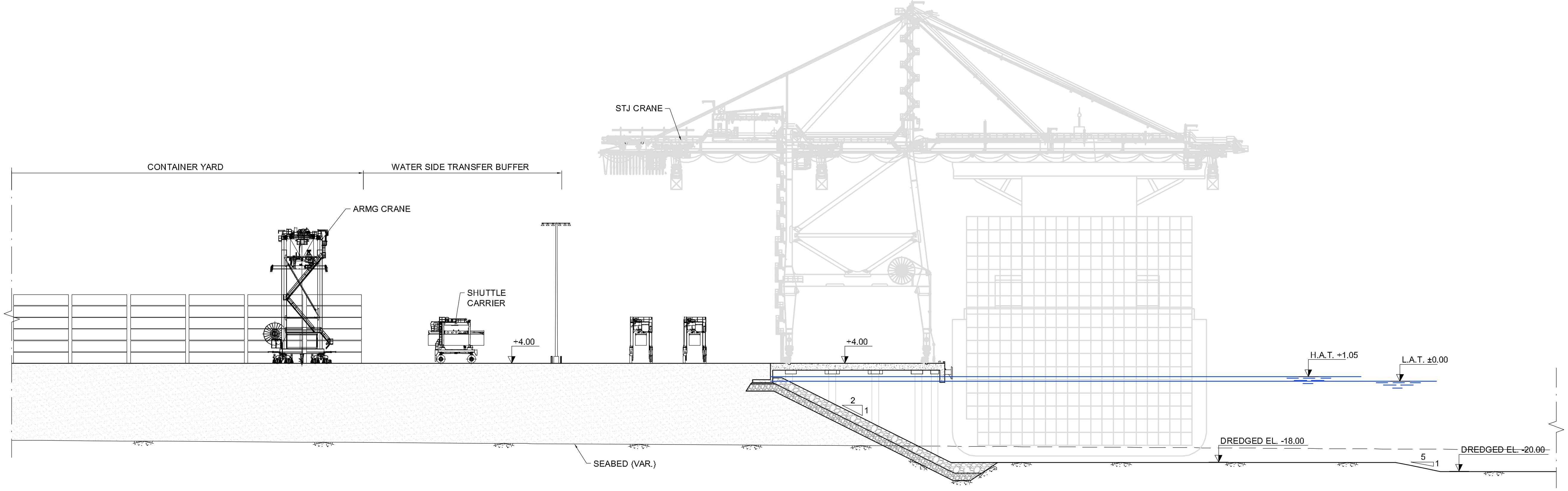

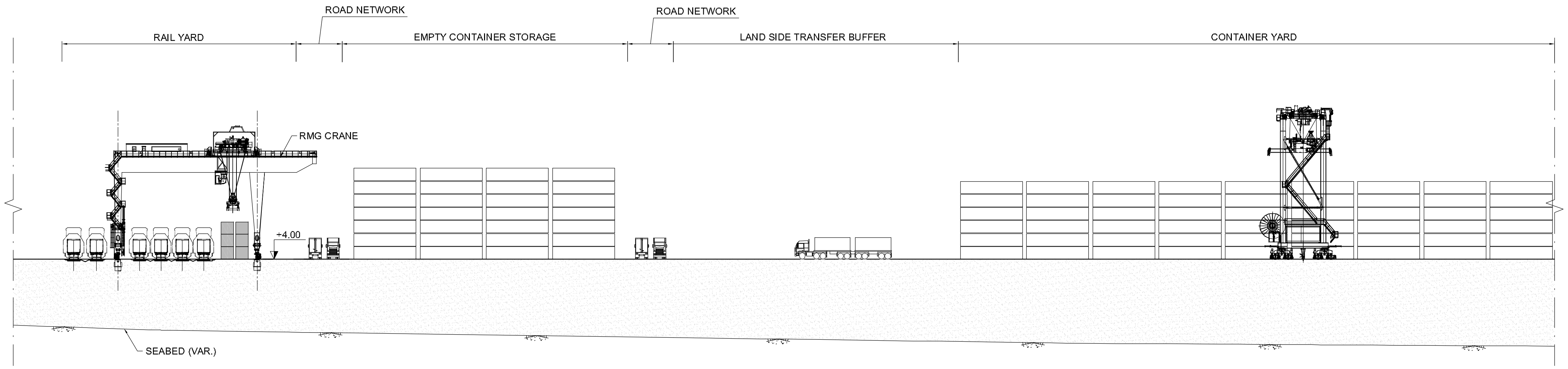

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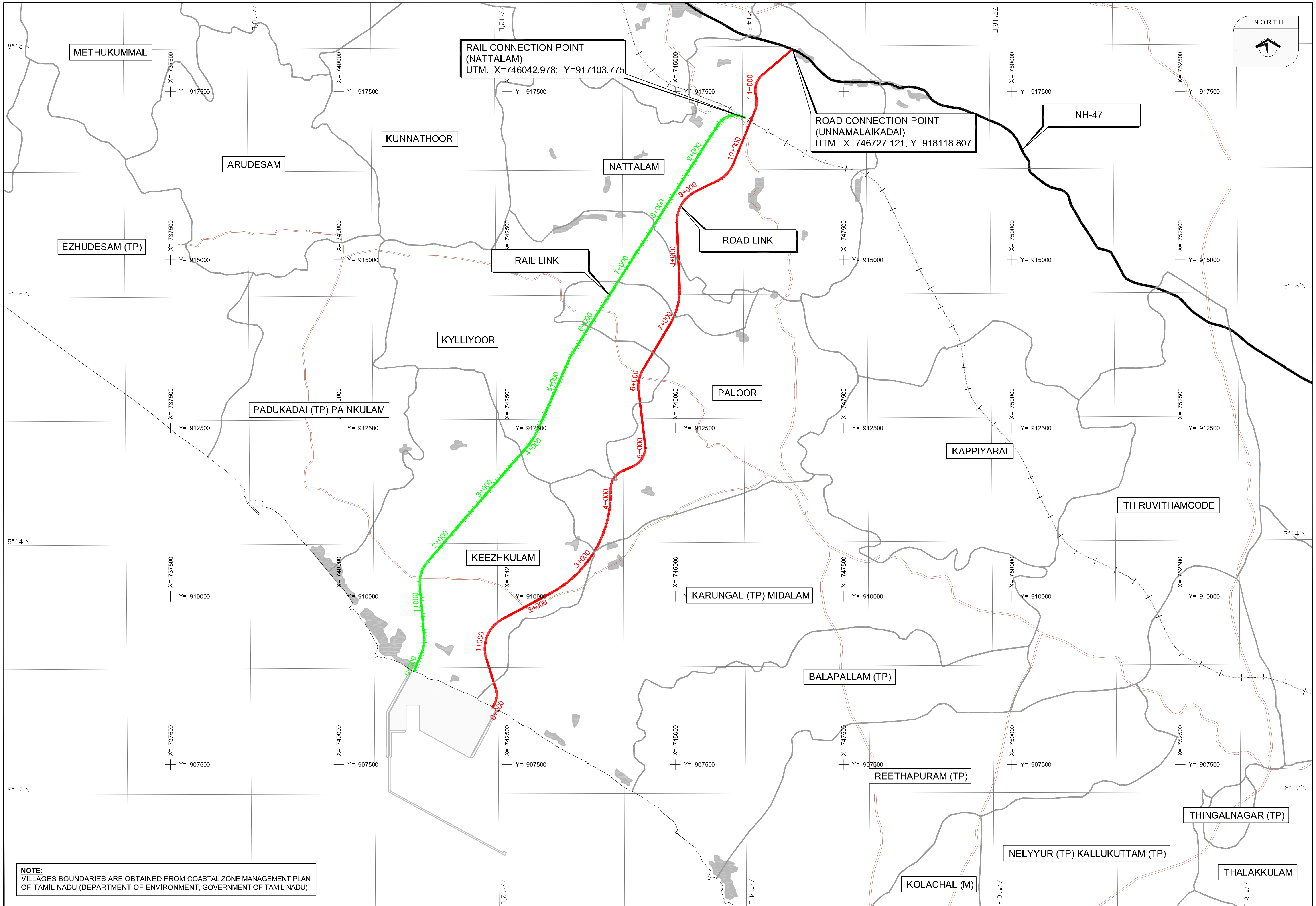

NOTE:
VILLAGES BOUNDARIES ARE OBTAINED FROM COASTAL ZONE MANAGEMENT PLAN OF TAMIL NADU (DEPARTMENT OF ENVIRONMENT, GOVERNMENT OF TAMIL NADU)

CLIENT:	CONSULTANTS:	PROJECT:	DATE:	SCALE:	DRAWING:	DRAWING N°:
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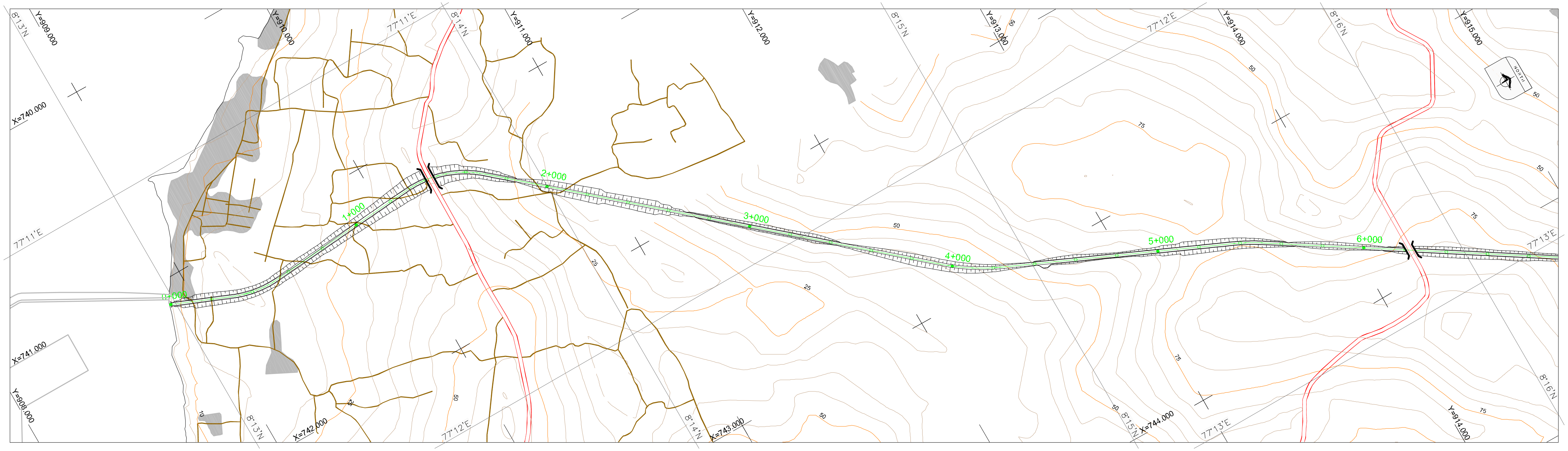
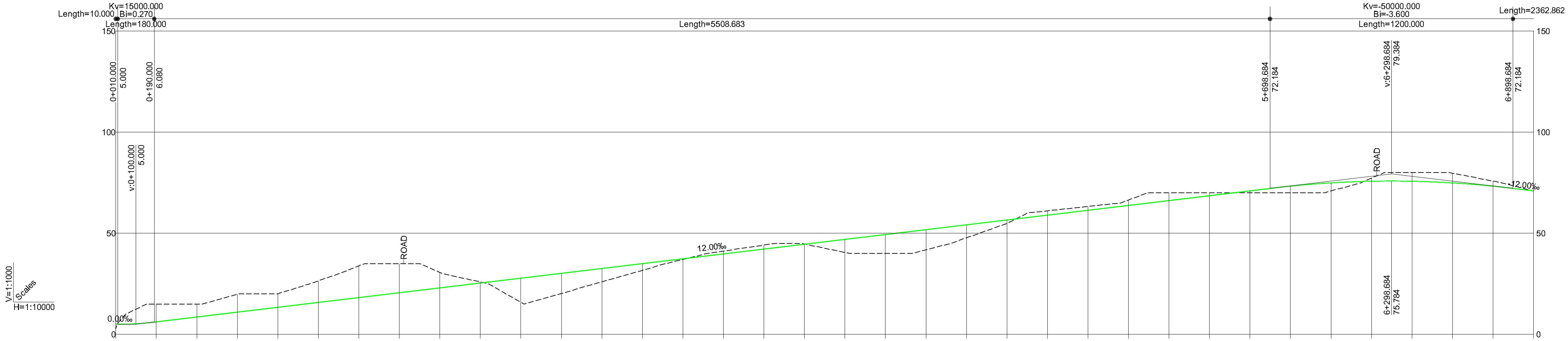
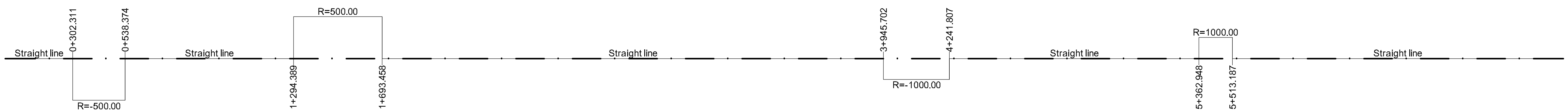




Progressive	Gradient Contour Height	Land Contour Height	Red contour height
0+000	5.000	2.752	2.248
	6.200	15.000	-8.800
	8.600	15.000	-6.400
	11.000	19.772	-8.772
	13.400	20.085	-6.685
	15.800	26.462	-10.662
	18.200	33.873	-15.673
	20.600	35.000	-14.400
	23.000	30.648	-7.648
	25.400	25.914	-0.514
1+000	27.800	15.911	11.889
	30.200	20.249	9.951
	32.600	25.972	6.628
	35.000	31.695	3.305
	37.400	37.058	0.342
2+000	39.800	41.178	-1.378
	42.200	44.154	-1.954
	44.600	44.646	-0.046
	47.000	40.492	6.508
	49.400	40.000	9.400
3+000	51.800	41.778	10.022
	54.200	47.738	6.462
	56.600	54.857	1.743
	59.000	61.074	-2.074
	61.400	63.237	-1.837
4+000	63.800	66.414	-2.614
	66.200	70.000	-3.800
	68.600	70.000	-1.400
	71.000	70.000	1.000
	73.297	70.000	3.297
5+000	74.892	70.843	4.049
	75.687	77.251	-1.564
	75.682	80.000	-4.318
	74.876	79.686	-4.810
	73.271	75.781	-2.510
7+000	70.968	70.880	0.089

Curvatures



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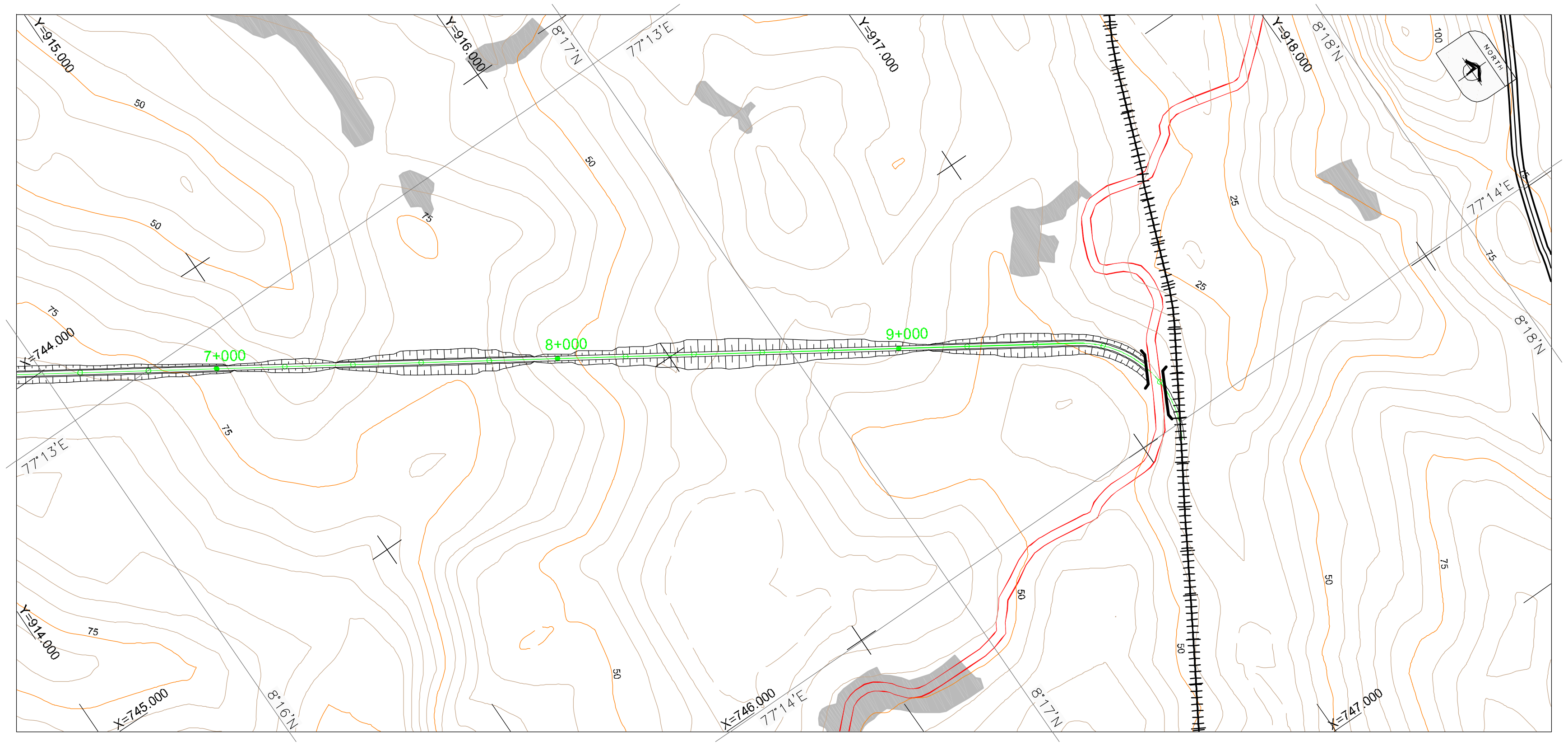

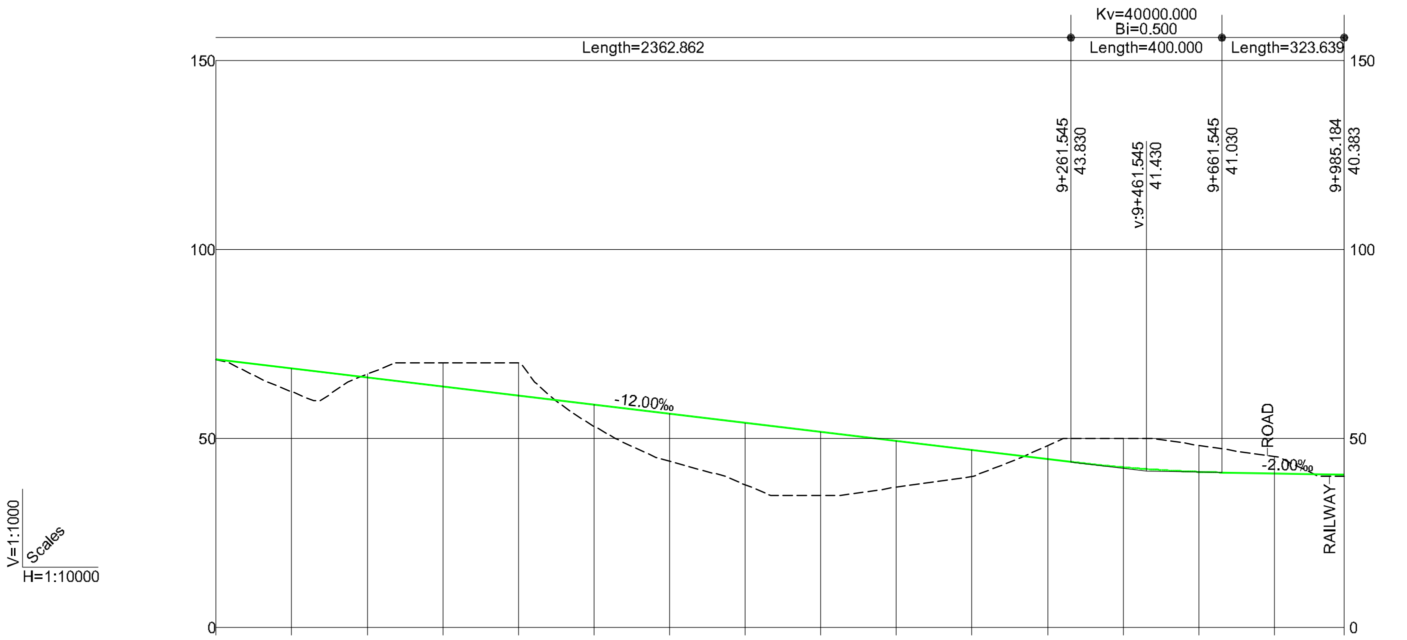

Gradient Contour Height	70.968	68.568	66.168	63.768	61.368	58.968	56.568	54.168	51.768	49.368	46.968	44.568	42.408	41.200	40.753	40.383
Land Contour Height	70.880	62.368	67.053	70.000	70.000	53.257	44.013	37.799	35.000	37.092	39.936	48.154	50.000	48.212	45.185	40.000
Red contour height	0.089	6.201	-0.885	-6.232	-8.632	5.712	12.556	16.370	16.768	12.276	7.033	-3.585	-7.592	-7.011	-4.432	0.383

Progressive: 7+000 — 8+000 — 9+000 — 9+985.184

Curvatures: Straight line — 9+521.965 — R=300.00

CLIENT:	CONSULTANTS:	PROJECT:	DATE:	SCALE:	DRAWING:	DRAWING N°:
V.O.CHIDAMBARANAR PORT TRUST	TYPSA BCG	RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU	AUGUST 2015	H= 10000 V= 1000	RAIL CONNECTIVITY. PLAN AND LONGITUDINAL PROFILE	08
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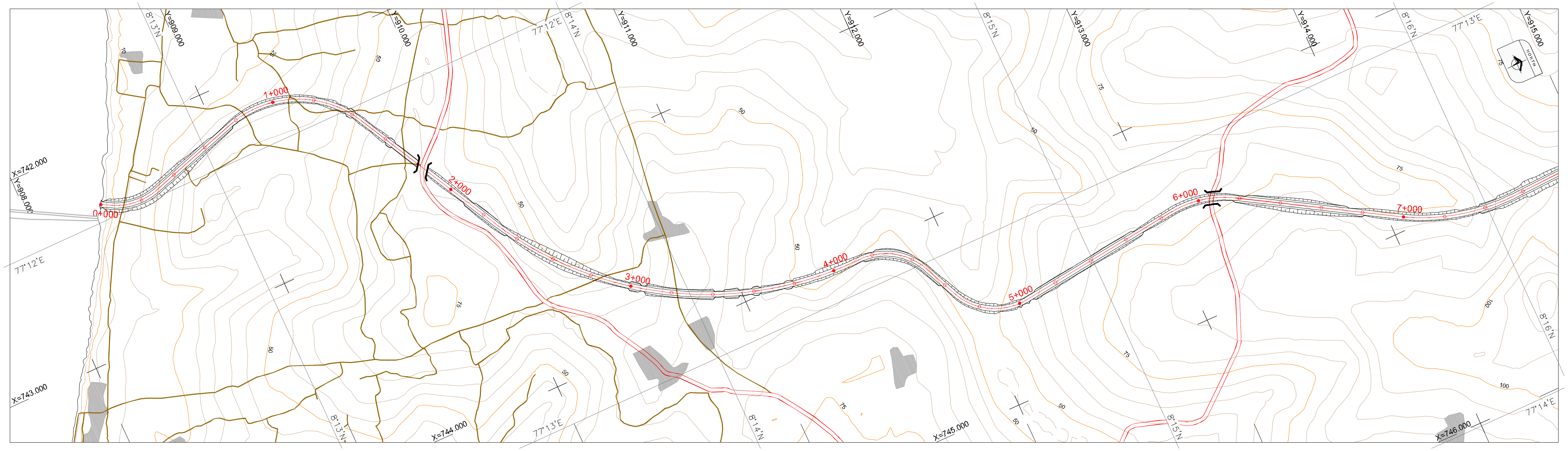
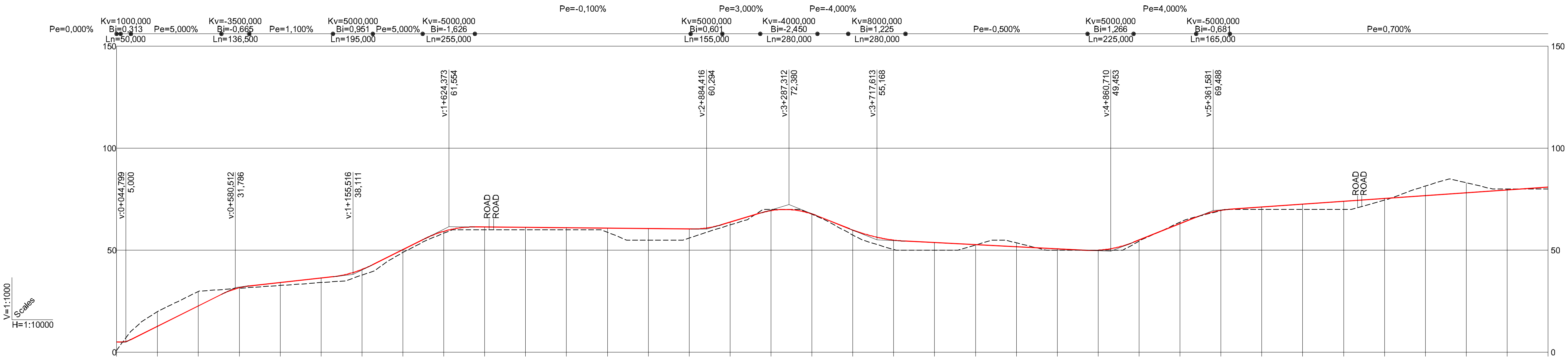


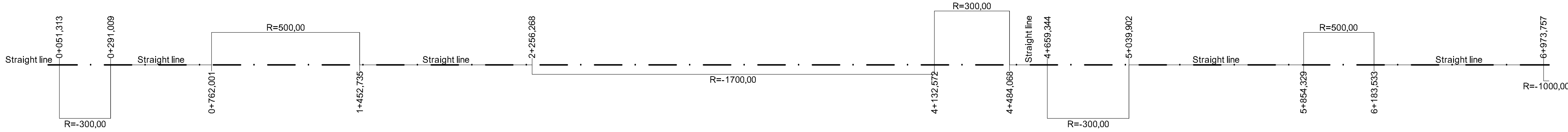


Gradient Contour Height	5,000	12,760	22,760	31,660	34,200	36,400	40,616	50,335	59,271	61,378	61,178	60,978	60,778	60,578	60,378	63,761	69,414	67,780
Land Contour Height	0,943	19,986	29,780	31,369	32,769	34,169	37,848	48,888	58,326	60,000	60,000	60,000	58,849	55,000	56,011	62,411	70,000	67,604
Red contour height	4,057	-7,226	-7,020	0,291	1,431	2,231	2,768	1,447	0,946	1,378	1,178	0,978	1,929	5,578	4,367	1,350	-0,586	0,176

Gradient Contour Height	59,904	54,964	53,756	52,756	51,756	50,756	50,025	55,024	63,024	69,562	71,157	72,557	73,957	75,357	76,757	78,157	79,557	80,957
Land Contour Height	57,488	50,330	50,000	52,566	53,624	50,000	50,000	54,423	63,743	69,426	70,000	70,000	70,000	74,548	81,435	83,061	80,000	80,000
Red contour height	2,416	4,634	3,756	0,190	-1,868	0,756	0,025	0,601	-0,719	0,137	1,157	2,557	3,957	0,808	-4,679	-4,905	-0,443	0,957

Progressive: 0+000, 1+000, 2+000, 3+000, 4+000, 5+000, 6+000, 7+000

Curvatures



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V.O.CHIDAMBARANAR PORT TRUST	TYPSA BCG	RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU	AUGUST 2015	H= 10000 V= 1000	ROAD CONNECTIVITY. PLAN AND LONGITUDINAL PROFILE	09
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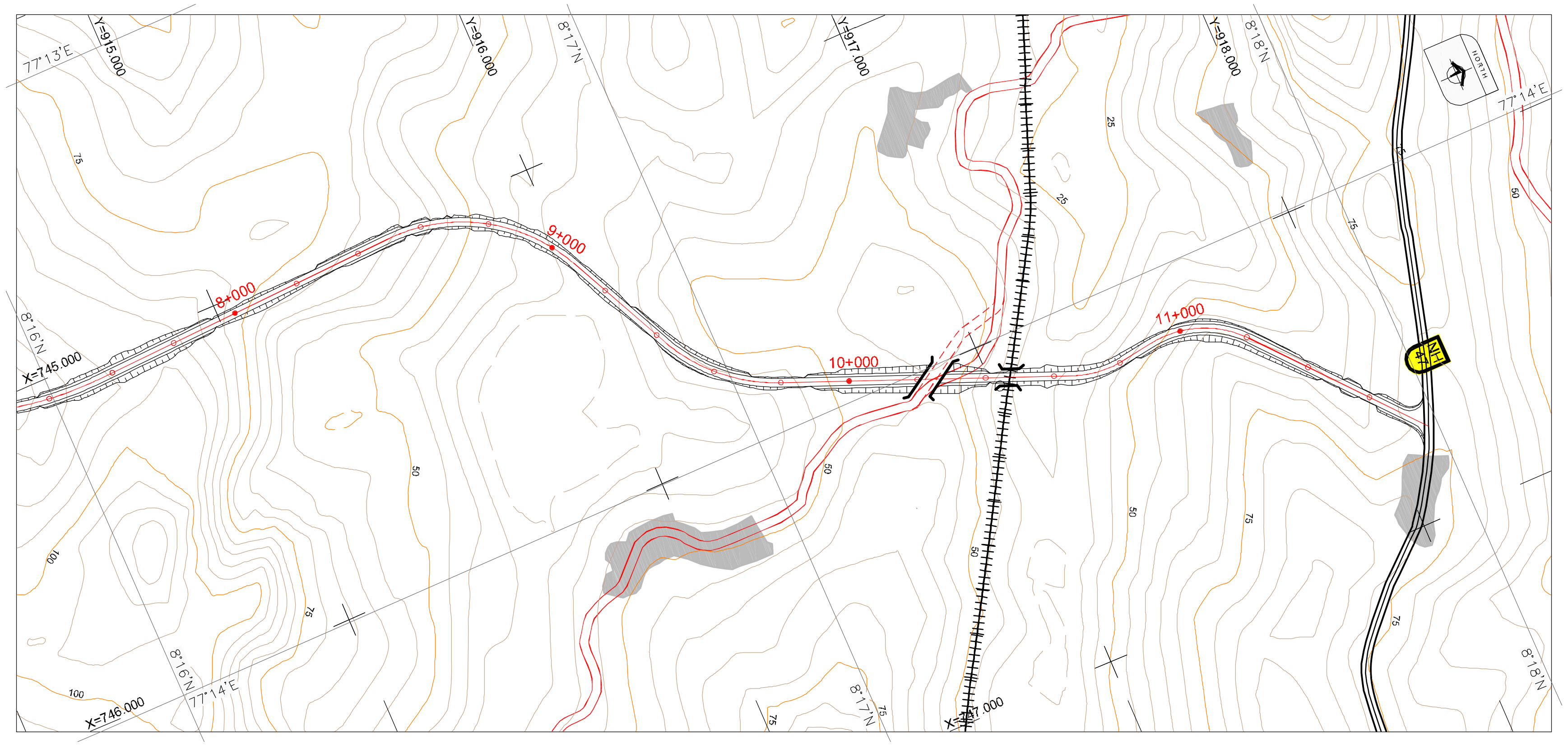
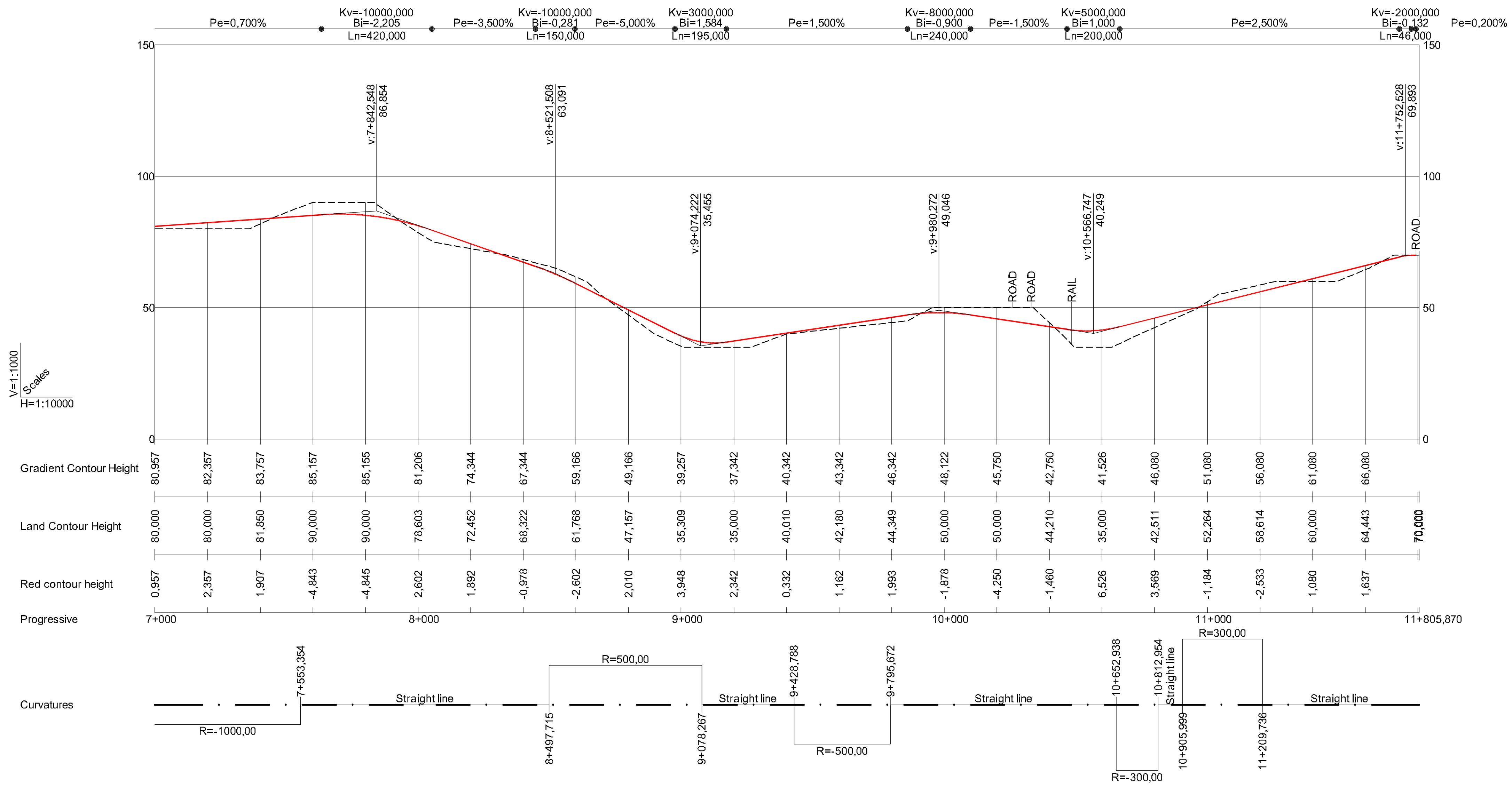




CLIENT:

V.O.CHIDAMBARANAR PORT TRUST

CONSULTANTS:

TYPSA BCG

PROJECT:

RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU

DATE: AUGUST 2015

SCALE: H= 10000 V= 1000

ORIGINAL: A-1

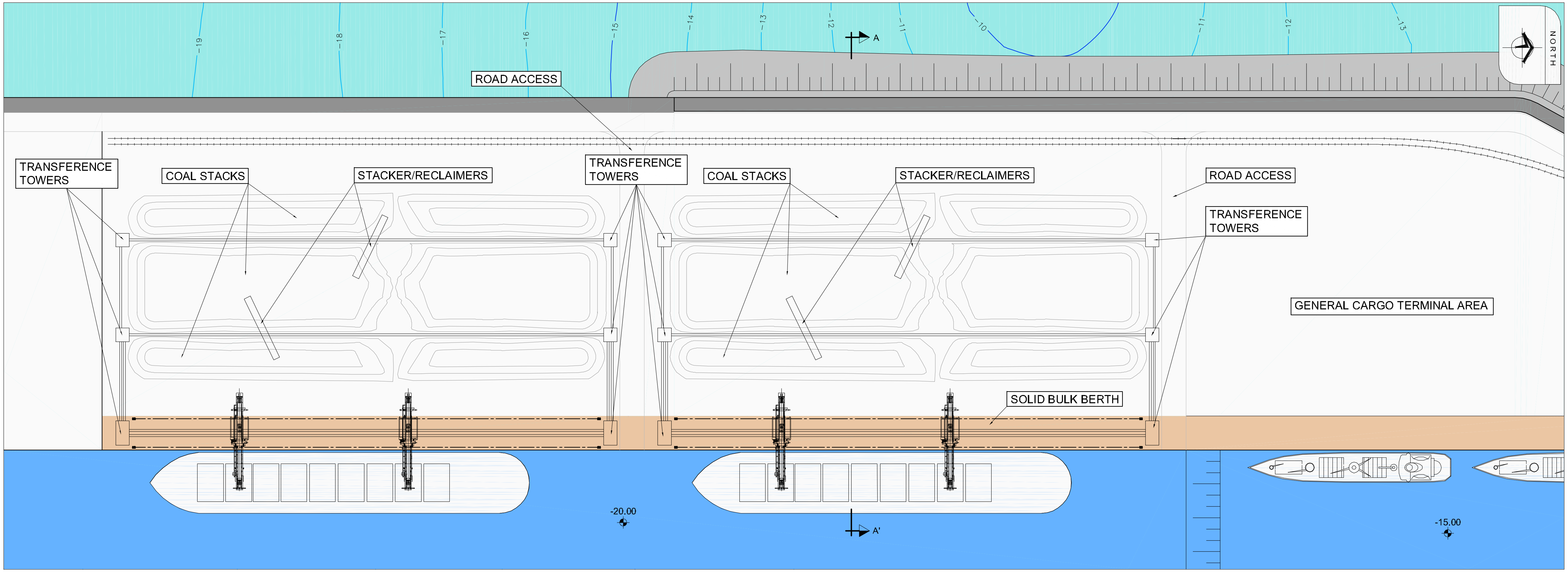
DRAWING:

ROAD CONNECTIVITY. PLAN AND LONGITUDINAL PROFILE

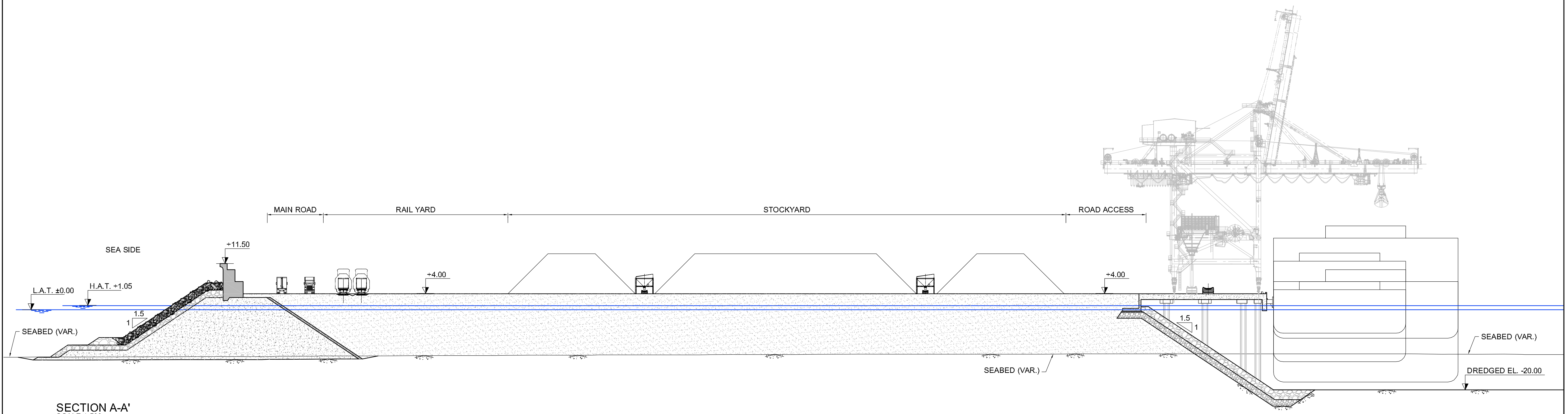
DRAWING Nº: 09

SHEET: 2 OF 2

FILE NAME: CP1832-FR-PL-09-02-CP-ConnectivityRoadLong-Ed2.dwg



LAYOUT
SCALE 1:1500



SECTION A-A'
SCALE 1:500

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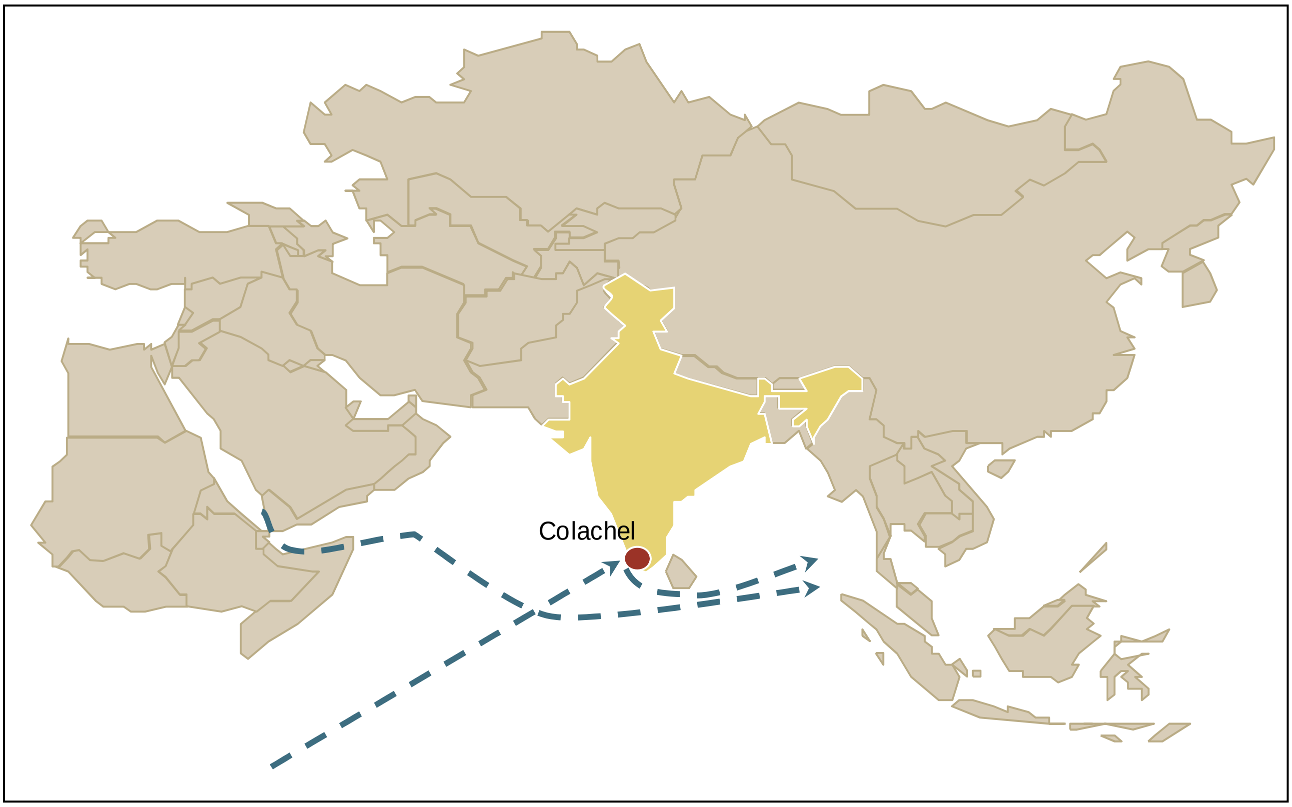
V.O.CHIDAMBARANAR PORT TRUST	TYPSA BCG	RAPID TECHNO-ECONOMIC FEASIBILITY REPORT FOR DEVELOPMENT OF COLACHEL PORT IN TAMILNADU	AUGUST 2015	AS INDICATED ORIGINAL: A-1	SOLID BULK TERMINAL FOR PHASE 2 AND 3. LAYOUT AND CROSS SECTION FILE NAME: CP1832-FR-PL-10-01-CP-SolidBulkTermLay-Ed2.dwg	10 SHEET: 1 OF 1



V.O.Chidambaranar Port Trust

Preparation of Rapid Techno-Economic Feasibility Report for Development of Colachel Port in Tamilnadu

TYPSA INGENIEROS CONSULTORES Y ARQUITECTOS

BCG

Final Report (Revised) Dated 14.08.2015

Volume 2 of 2: Annexures

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ANNEXURE 1:

PHOTOGRAPHIC REPORT

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1. KANYAKUMARI

Kannyakumari: Sunset point

Kovakulam coast line general view.

Thiruvalluvar Statue and Kanyakumari temple.

Kanyakumari fish landing site

Kanyakumari fish market

2. MANAVALAKURICHI

	
Kadiapattinam. landing site. Manavalakurichi Port location	Kadiapatinam village
	
Valliyar estuary formed by the river Valloiyar nearManavalakurichi.	Manavalakurichi beach
	
Kadiapattinam seafront. Manavalakurichi off-shore Port. Location of the connection bridge	View of the Manavalakurichi off-shore Port location

	
Sand stockpiled by Indian Rare Earth limited	
	
Government plot landmark at the right bank of the Valliyar estuary.	Entrance gate of Indian Rare Earth limited Housing colony,

3. COLACHEL

Colachel Town

A view of Colachel Fishing harbour taken from the nearby pier.

View of the eastern beach section

At the back in the picture the proposed location of Colachel Port

Small sand beaches, pocket beaches, at Colachel, western to the proposed Port location

	
Colachel fishing harbour upgrading works	Colachel Fishing harbour. Fish landing
	
Mechanized boats in the fishing harbour	Colachel harbour fish market
	
Tuna fish catch.	Prawns catch

4. ENAYAM

Enayam town, west to the stone groyne

Enayam town east to the stone groyne

Enayam town, RMS wall

Enayam beach. Shoreline erosion phenomena

Shipyard near the coast

Coastline of the proposed Enayam Port Location

	
Coconut tree plantation inland. Port inland area	Water pond. Port inland area

5. OTHER SITES ALONG THE STUDY AREA


Muttom fishing harbour

Paddy landscape. Manavalakurichi-Nagercoil road

Fishermen at Midalam beach

Sand dune along the coastline road (Manakudi to Periyakadu)

Coastline road eroded by the sea

	
Chinamuttom fishing harbour	Casuarina plantations on sand dunes. Manakudi
	
Manakudi town	Tourism developments. Manakudi to Annainagar road
	
Water tank at Mandaikadu	Traditional catamarans

ANNEXURE 2:
WAVE CLIMATE

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1. INTRODUCTION

The goal of this work is define the wave climate in coastal areas at some particular locations near the area of study.
The characterization of wave climate offshore and the propagation to shallow water areas are necessary for the design of port structures (breakwaters, sills, etc.).
The most important objectives are seen below:

- Characterization of wave climate offshore is realized analyzing the reanalysis databases from 1950 to 2014
- A maximum dissimilarity selection algorithm (MDA) is applied in order to obtain a representative subset of sea states in deep water areas, guaranteeing that all possible sea states are represented and capturing even the extreme events.
- These sea states are propagated using a wave propagated model (SWAN) to shallow water areas.
- The time series of the propagated sea state parameters at a particular location are reconstructed using a non-linear interpolation technique based on radial basis functions (RBFs).
- Characterization of wave climate in shallow water at a particular location.

2. DATA SOURCES

2.1. THE OFFSHORE WIND DATA (CFSR):

The Climate Forecast System (CFS) is a model representing the global interaction between the Earth's oceans, land, and atmosphere developed by the US National Centers for Environmental Prediction (NCEP). It is a global third generation reanalysis product. The CFSR is a high resolution, coupled atmosphere-ocean-land surface-sea ice system designed to provide the best estimate of the state of these coupled domains over the period from 1979 to 2010 (Saha et al., 2010). CFS uses the latest scientific approaches for assimilating observations from many data sources: surface observations, upper air balloon observations, aircraft observations, and satellite observations. The Climate Forecast System Reanalysis (CFSR) is an effort to generate a uniform, continuous, and best-estimate record of the state of the ocean-atmosphere for use in climate monitoring and diagnostics. CFSR stands out by its high resolution and advances in data assimilation techniques. Here, the near-surface winds from CFSR is freely provided. Please, refer to the source of this dataset for details of the quality and validation processes.

2.2. THE GOW (GLOBAL OCEAN WAVES) DATABASE.

Wavewatch IIII (WWIII, Tolman, 2002) is a third generation wave model developed at NOAA-NCEP. WWIII solves the spectral action density balance equation for wave number direction spectra. The implicit assumption of this equation is that properties of the medium (water depth and current) as well as the wave field itself vary in time and space scales that are much larger than the variation scales of a single wave. The model can generally be applied to large spatial scales and outside the surf zone. Parameterizations of physical processes include wave growth and decay due to the actions of wind, nonlinear resonant interactions, dissipation (`whitecapping') and bottom friction. Wave interactions with currents were not considered in this hindcast.
The wind fields used to force waves come from the global re-analysis NCEP/NCAR RI (Kalnay et al., 1996). The bathymetry used in the wave reanalysis originates from the General Bathymetric Chart of the Oceans

(GEBCO, http://www.gebco.net). The bathymetric portion was generated by combining quality-controlled ship depth soundings, with predicted depths between the sounding points guided by satellite-derived gravity data [Smith and Sandwell, 1997].

More than 60 years of historical wind-generated offshore waves were performed for the last half century. The wave hindcast outcomes provide hourly time series of significant wave height, mean wave period, peak frequency and mean wave direction for all the grid points of the computed grid. More details can be found in Reguero et al. 2012.

2.3. THE CORRECTION PROCEDURE OF THE GOW GRID-POINT.

In order to reduce possible discrepancies of numerical results with respect to the instrumental data, a correction procedure using satellite info has been applied to the GOW significant wave height. The discrepancies could be due to flaws in the wind fields, insufficient model resolution, unresolved island blocking, imperfect bathymetries, etc.

The applied calibration technique is a parametric method based on a nonlinear regression problem. Briefly, the correction parameters vary smoothly along the possible directions by means of cubic splines, allowing different corrections depending on the direction. Corrections are made on empirical quantile information on a Gumbel probability paper scale giving more relevance on the calibration procedure to the maximum data, which is more important from the design point of view. A detailed description of the methodology can be found in Minguez et al., 2011.

2.4. THE GOT (GLOBAL OCEAN TIDES) DATABASE.

GOT dataset provide hourly time series of astronomical tide for a selected period. It is generated using the harmonic constants derived from the TPXO7.0 global tides model developed by Oregon State University (http://volkov.oce.orst.edu/tides/global.html).

TPXO7.0 is a current version of a global model of ocean tides, which best-fits, in a least squares sense, the Laplace Tidal Equations and along track averaged data from TOPEX/Poseidon and Jason (on TOPEX/POSEIDON tracks, since 2002). The methods used to compute the model are described by Egbert et al. (1994) and further detail is provided by Egbert and Erofeeva (2002). The database includes eight primary constants (M2, S2, N2, K2, K1, O1, P1, Q1), two long period constituents (Mf, Mm), and 3 non-linear (M4, MS4, MN4) harmonic constituents, provided in a global grid of 1440 x 721 points, at 1/4 degree resolution full global grid. This information is used to reconstruct hourly time series of tide in any location worldwide using the tool t_tide (Pawlowicz et al., 2002).

3. REANALYSIS DATABASES

This information has been extracted from two locations points with hourly temporal resolution:

- Southwest India [Lon=76.50ºE, Lat=8.00ºN]
- Southeast India [Lon=78.00ºE, Lat=8.00ºN]

The databases contain met-ocean information with hourly time series of several parameters of the sea state, wind speed and wind direction and sea level variability due to tide:

- Hs: Significant wave height (metres). Calibrated directionally using satellite data.
- Tm: Mean wave period (seconds).
- Fp: Peak frequency (Hz). Calculated from the one-dimensional frequency spectrum using parabolic fit around the discrete Peak.
- θHs: Mean wave direction (degr., meteorological convention).
- W: wind speed at 10 metres above the sea surface (m/s)
- Wdir: Wind direction at 10 metres above the sea surface (degr., meteorological convention).
- Tide: tidal level (m) without meteorological effects /storm surge.

The locations are showed in figure 1.

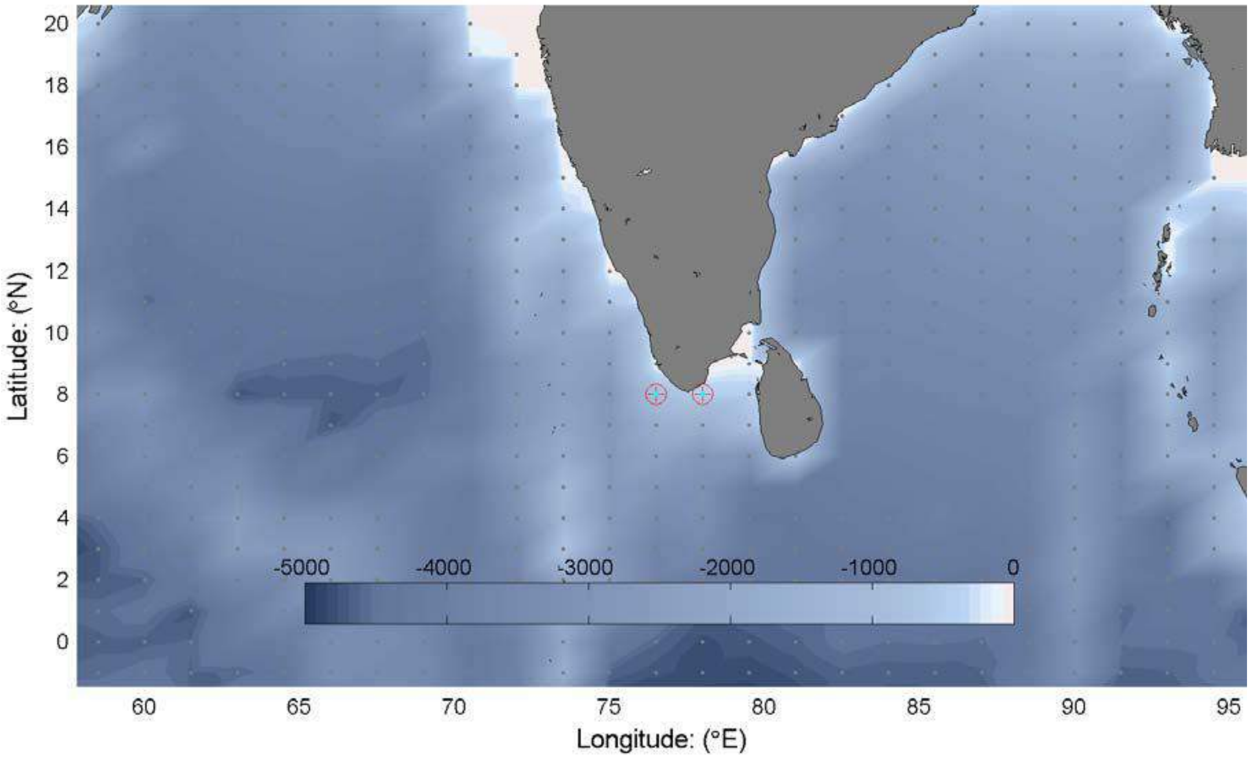
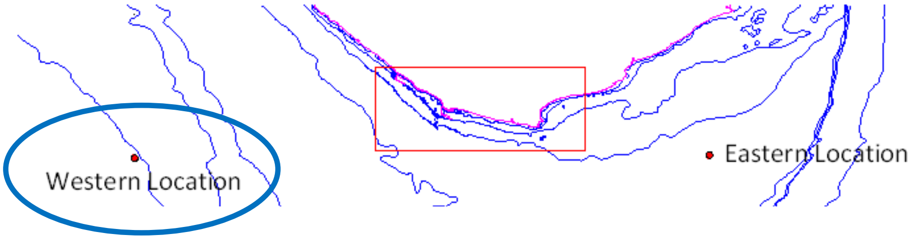


Figure 1. Locations points of reanalysis databases

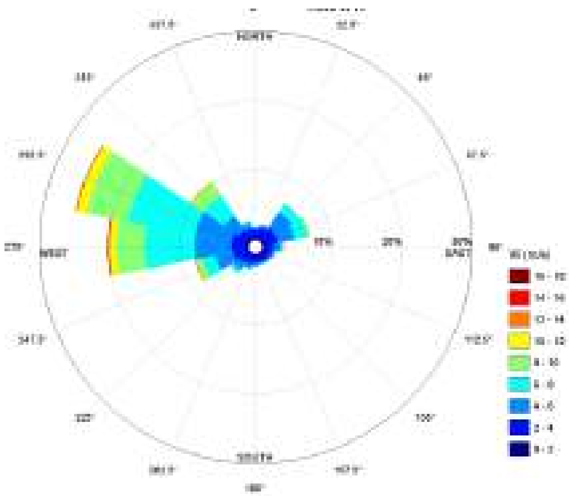
3.1. THE OFFSHORE WIND DATA

Two databases offshore are available. The predominant wind directions are West and Northwest in the Western Location, that are represented by Wind roses

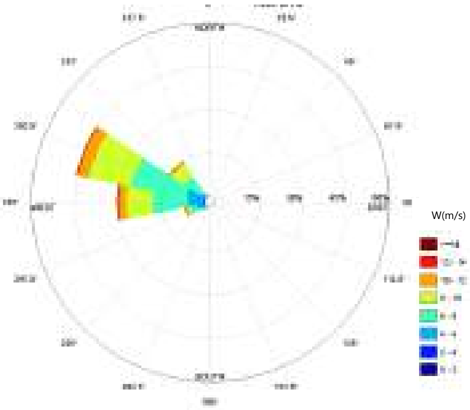
Western location



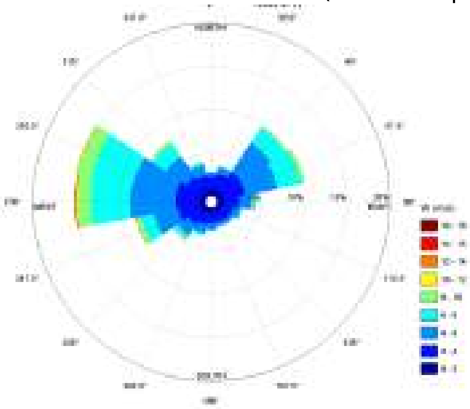
Winds Rose



Winds in Monsoon Period

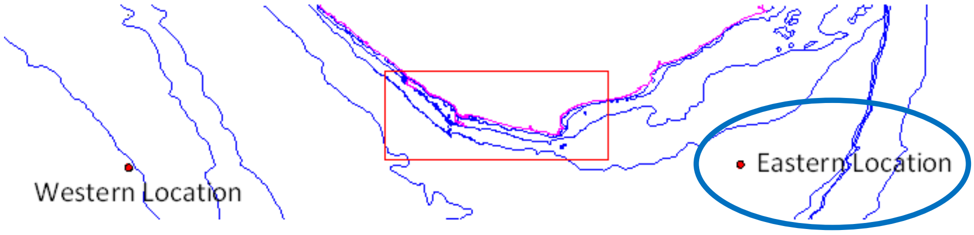


Winds in No Monsoon Period (June to September)

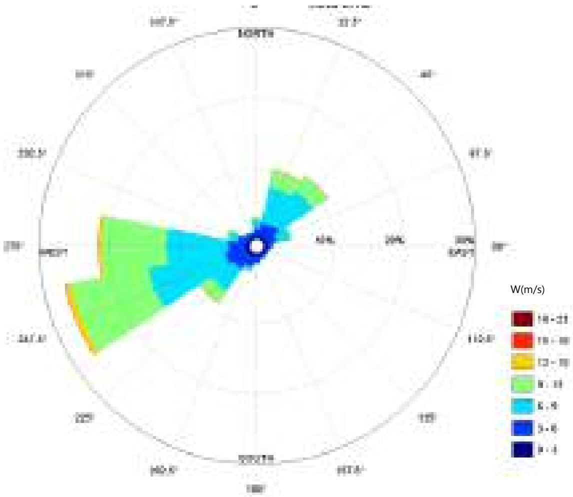


The predominant wind direction during monsoon period in the western location, from June to September, is West to North-west .During non-monsoon periods, the predominant wind directions are from North-east during the morning and West during the evening. The maximum wind speed observed was 18m/s from West direction.

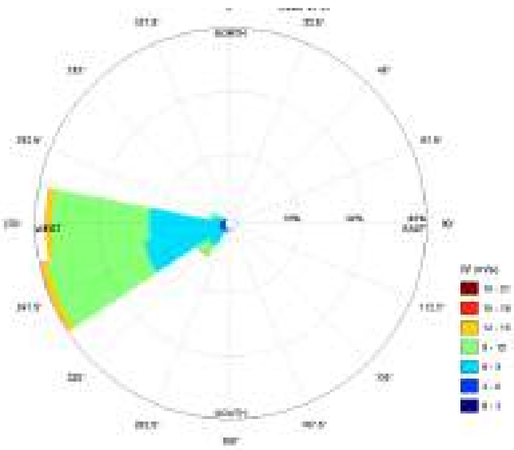
Eastern location



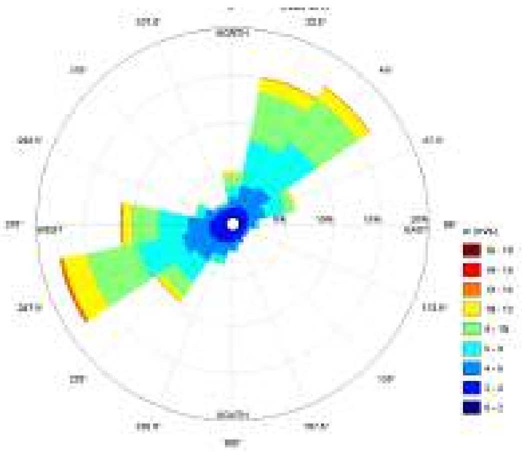
Winds Rose



Winds in Monsoon Period



Winds in No Monsoon Period (June to September)



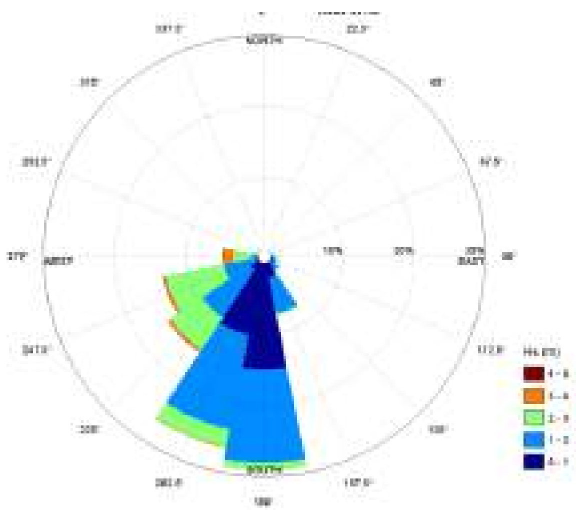
The predominant wind direction during monsoon period in the eastern location, from June to September, is West to South-West. During non-monsoon periods, the predominant wind directions are from North-east during the morning and West during the evening.

3.2. THE GLOBAL OCEAN WAVES DATABASE.

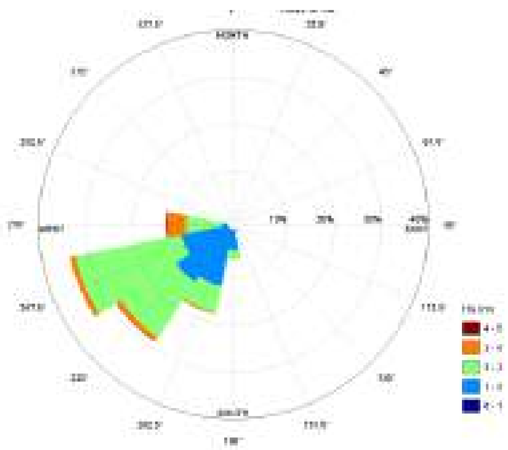
A brief description is represented by wave roses in each location and in conclusion the dominant waves comes from South-southwest.

Western location Wave Rose

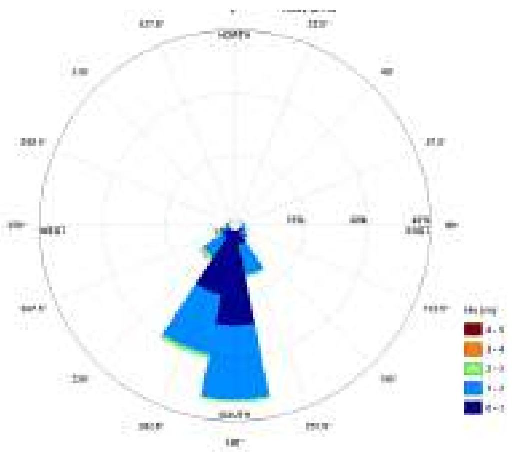
Wave Rose Year Round



Wave Rose in Monsoon Period



Wave Rose in No Monsoon Period

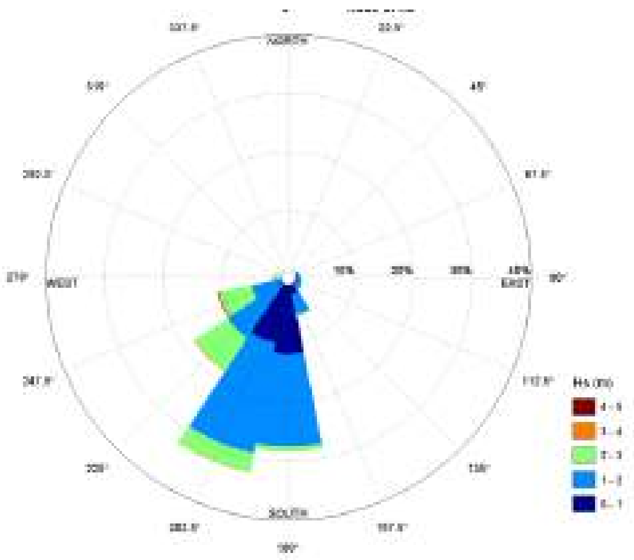


The predominant wave direction is from South to South-Southwest, but the biggest height ones comes from the South-west to the West

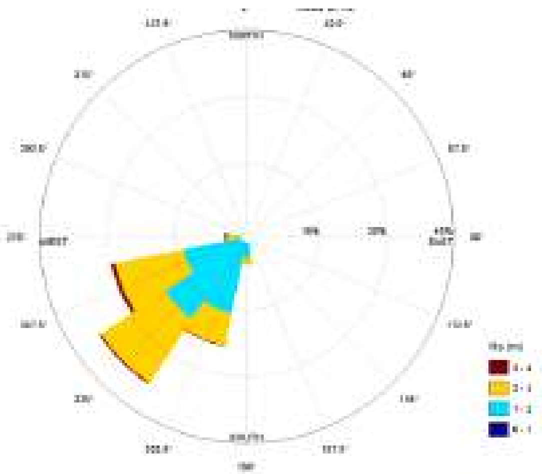
During Monsoon period the predominant directions are Western-south-western and Southwest. The biggest waves come from the West with a height of 4-5 meters. And during non-monsoon periods, the predominant wave direction are South and South-Southwest.

Eastern location Wave Rose

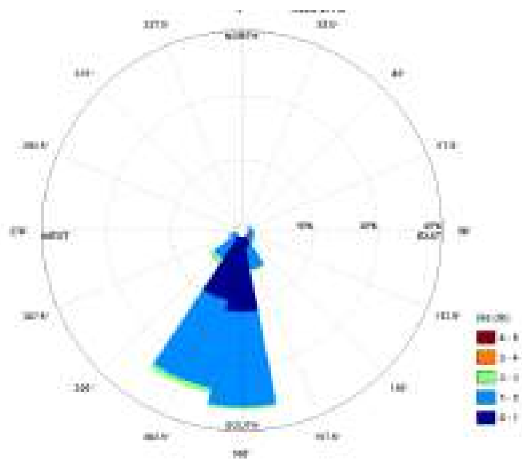
Wave Rose Year Round



Wave Rose in Monsoon Period



Wave Rose in No Monsoon Period



The information is approximately the same as the western location, with predominant direction from South to South-Southwest in the year round, and the predominant directions are Southwest during Monsoon period and South and South-Southwest during non-monsoon periods.

MEAN REGIME AND EXTREME REGIME

The follow Figures show the long-term distribution for significant wave height (Hs) in mean regime and extreme regime in each location

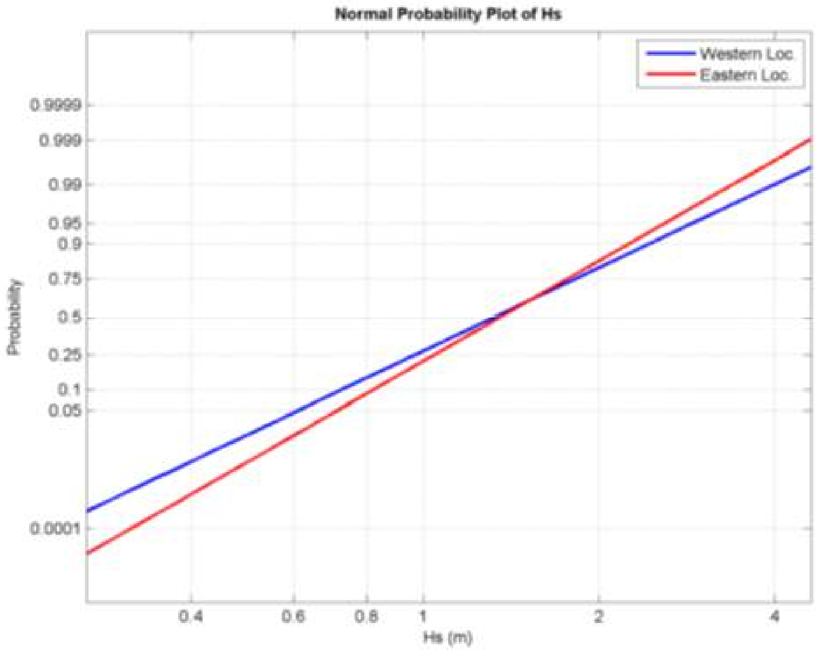


Figure 2. Significant wave height (Hs) in mean Regime

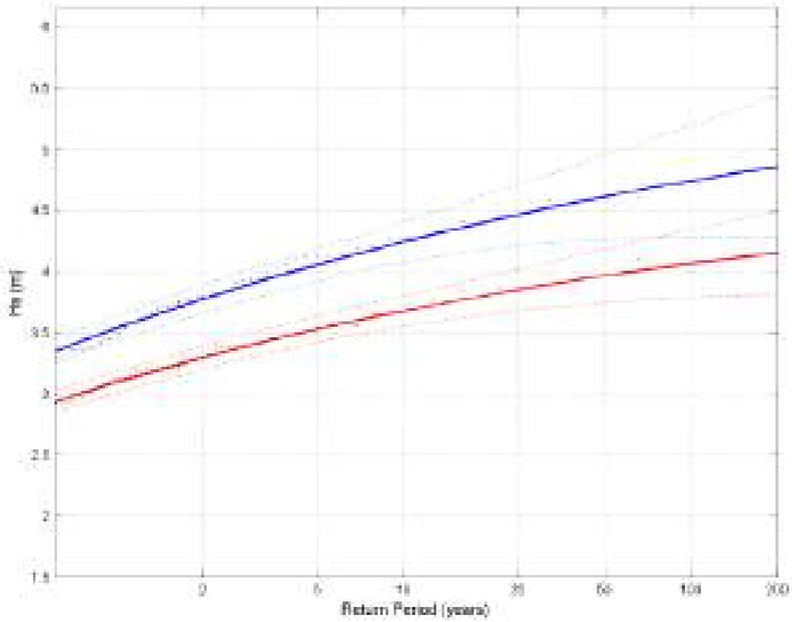


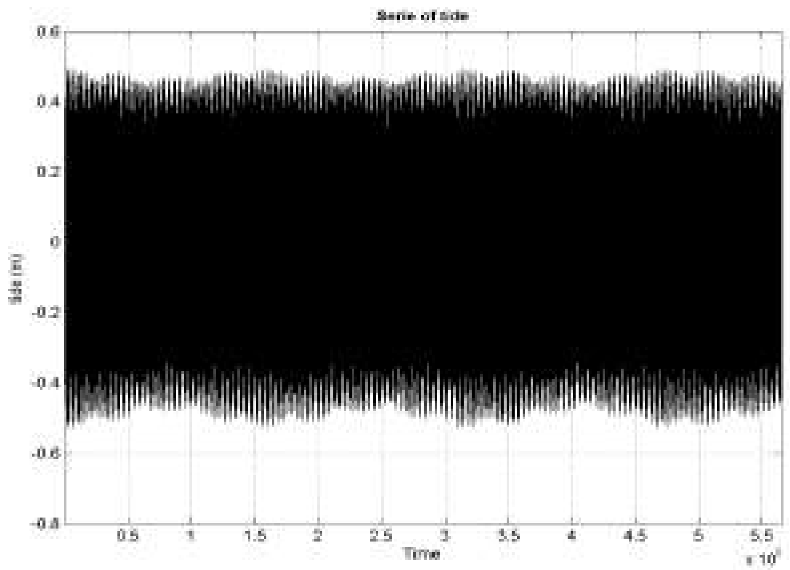
Figure 3. Significant wave height (Hs) in Extreme Regime

3.3. GLOBAL OCEAN TIDES DATABASE.

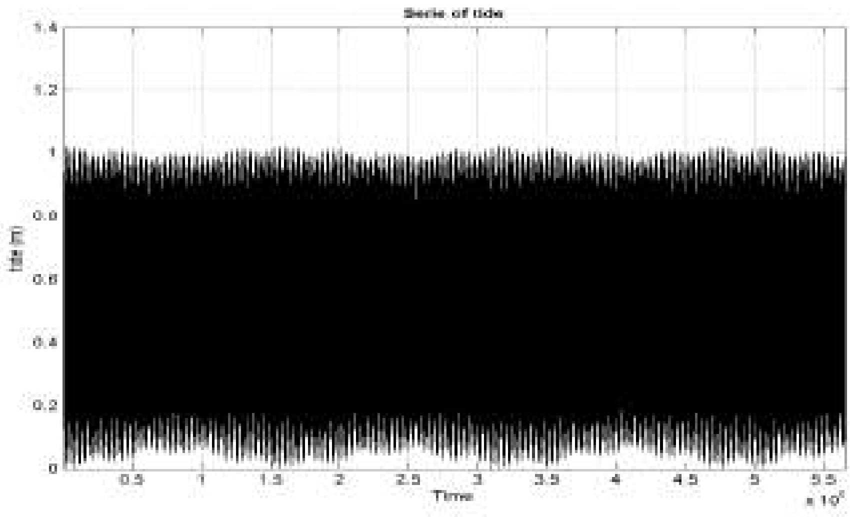
GOT dataset provides hourly time series of astronomical tide for a selected period.

Tide information is measured respect the Mean Sea Level, the information has been transformed taken the lowest astronomical tide (LAT) as the zero of the tide information.

Tide with reference to the Mean Sea Level



Tide with reference to the Lowest Astronomical Tide



The tidal levels are shown in the table below:

HAT:	Highest Astronomical Tide. The elevation of the highest predicted astronomical tide expected to occur. at least once a year	1.05
HHWS	Highest High Water Spring	1.04
MHHW	Mean Higher High water. The mean of the higher of the two daily high waters over a long period of time. When only one high water occurs on a day, this is taken as a higher high water .	0.83
MLHW	Mean Lower High Water. The mean of the lower of two daily high waters over a long period of time. When only one high water occurs on a day, no value is printed in the MLHW column, indicating that the tide is diurnal .	0.67
MHLW	Mean Higher Low Water. The mean of the higher of the two daily low waters over a long period of time. When only one low water occurs on a day, no value is printed in the MHLW column, indicating that the tide is diurnal .	0.41
MLLW	Mean Lower Low Water. The mean of the lower of the daily low waters over a long period of time. When only one low water occurs a day, this is taken as the lower low water	0.25
LLWS	Lowest Low Water Spring	0.02
LAT	Lowest Astronomical Tide. All heights have been taken above the lowest astronomical tide	0.00
GT	Great Diurnal Range The difference in height between mean higher high water (MHHW) and mean lower low water (MLLW).	0.58

4. TRANSFORMATION WAVE FROM DEEP WATER TO SHALLOW WATER

Sea states are propagated using a wave propagation model (GUIH-SWAN) from deep water to shallow water areas in different points of interest.
Firstly a maximum dissimilarity selection algorithm (MDA) has been applied in order to obtain a representative subset of sea states in deep water areas. The MDA has been selected 200 multivariate sea states uniformly distributed over data, covering the edges and sampling the variability of deep water climate.

Secondly this subset has been propagated to shallow water. The propagation model, GUI_SWAN, consists in a numerical approximation of waves from deep water to shallow water near the coast in order to evaluate the variability of the wave climate. It is a GUI which facilitates pre-processing and post-processing of the information needed to implement the SWAN model (Booij et al. 1999) (Simulating Waves Nearshore, Cicle III version 40.91).
SWAN is a third-generation wave model, developed at Delft University of Technology that computes random, short-crested wind-generated waves in coastal regions and inland waters. This model can be

used in any geographical scale for all processes related to the generation of gravity waves by surface wind.

Finally the reconstruction of time series of wave parameters near shore has been carried out by an interpolation technique based on radial basis functions (RBFs). The RBF technique has proves to be a powerful technique to reconstruct time series of sea state parameters being each sea state at deep water .

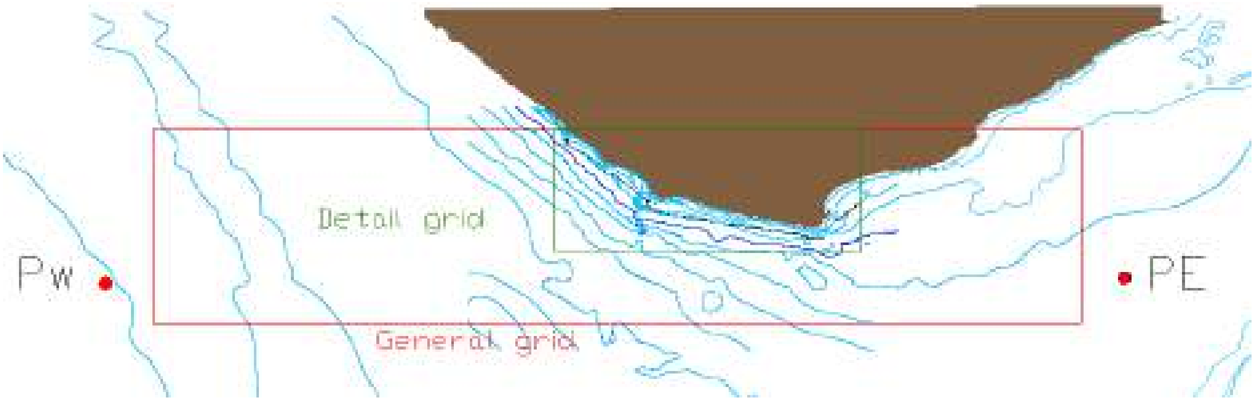


Figure 4. Bathymetry and grids(General grid and Detail grid)

A number of points of interest are located near the coast (P1,P2....P21).

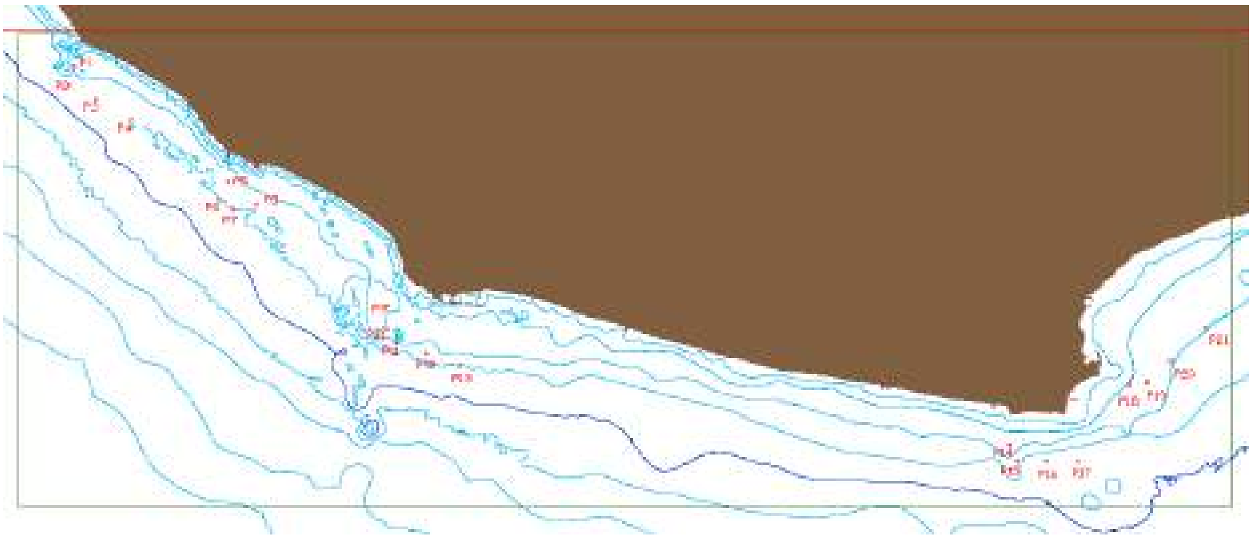
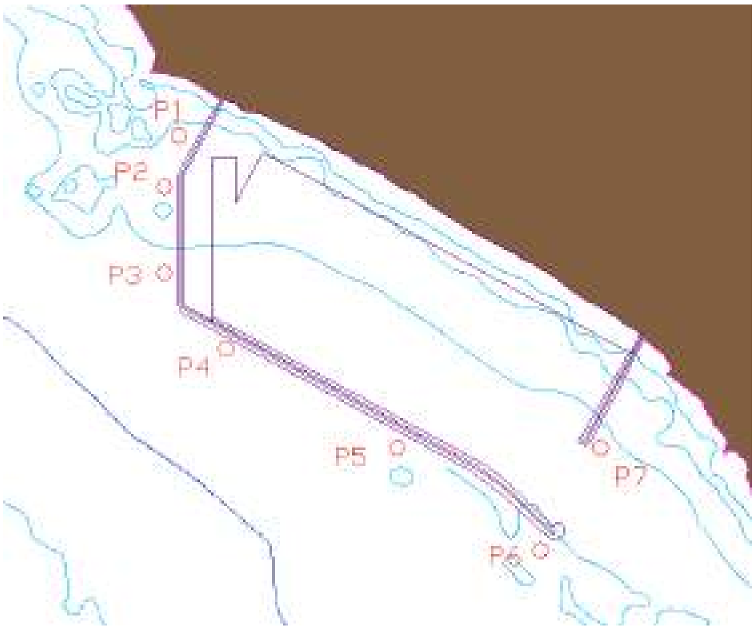


Figure 5. Points of interest

5. CHARACTERIZATION OF WAVE CLIMATE IN SHALLOW WATER

Wave climate in shallow water has been characterized in mean regime and extreme regime

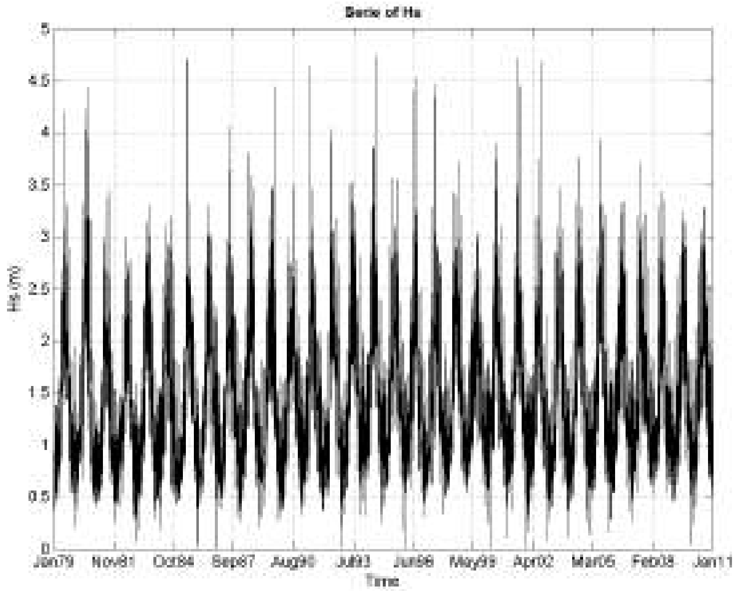


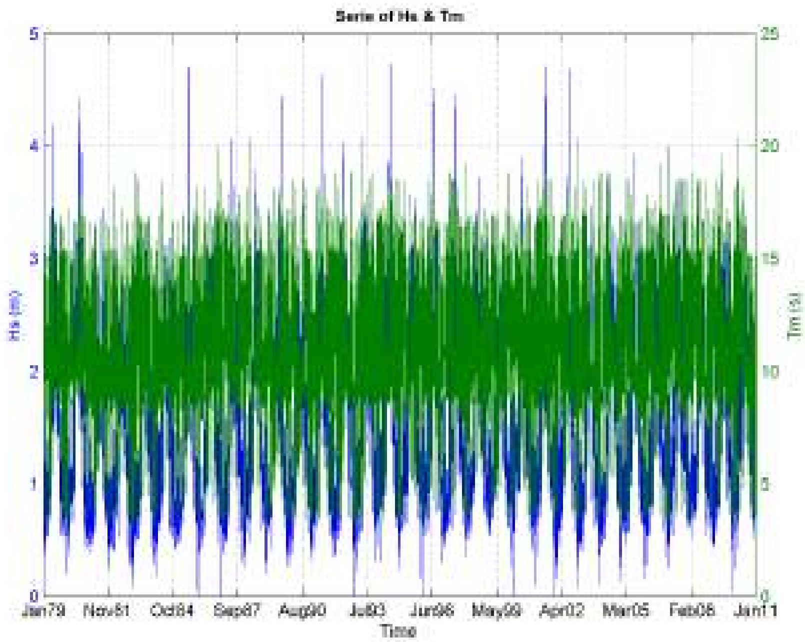
The result of this propagation is obtain a wave height which has been taken as the first step for the preliminary design. So mean regime and extreme regime have been estimated in each point. All values are shown in the next table:

Shallow water Points	Mean Regime	Extreme Regime (200 years)
P1	1,78	4.00
P2	2,08	5.00
P3	2,00	4.80
P4	2,02	4.50
P5	2,02	5.00
P6	2,06	4.80
P7	1,99	4.90

The characterization of wave climate is:

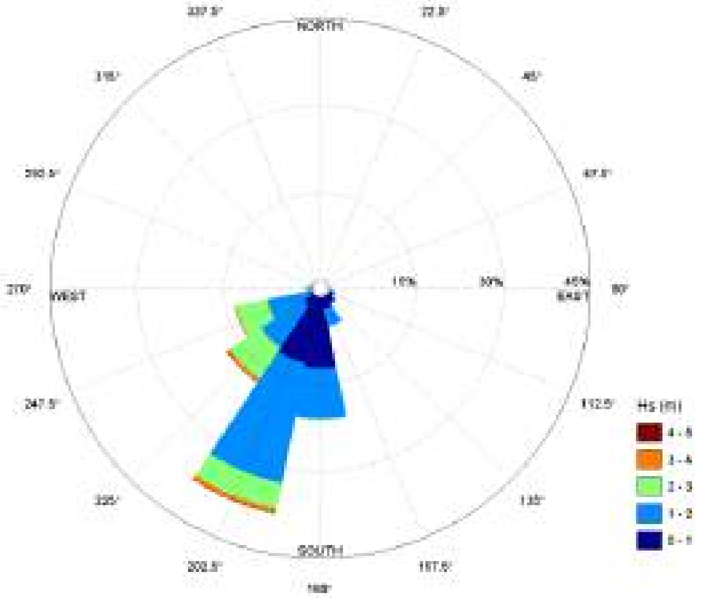
5.1. WAVE SERIE AND PERIOD SERIE





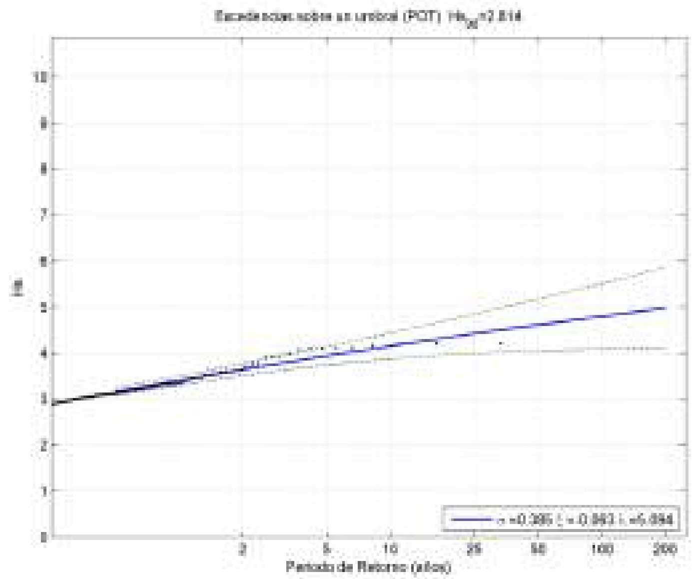
5.2. WAVE ROSES

Wave roses in all points are very similar, and all of them have the principal direction from the Southwest.



5.3. EXTREME REGIME

The Extreme Regime is represented in this figure for one of the point that have been propagated. The value which has been chosen as extreme value is the central estimation of the graph for the return period of 200 years.



5.4. OCURRENCE TABLE (OFFSHORE DATABASE)

	lower Tp	upper Tp	class Tp 1	class Tp 2	class Tp 3	class Tp 4	class Tp 5	class Tp 6	class Tp 7	class Tp 8	class Tp 9	class Tp 10	total
lower Hs			0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	565364
upper Hs			0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	
class Hs 1	2	3.9	0.0000	0.0548	0.1576	0.0481	0.0103	0.0018	0.0002	0.0000	0.0000	0	0.2727
class Hs 2	3.9	5.8	0.0042	0.3658	1.5714	1.2093	0.1955	0.0071	0.0000	0.0000	0.0000	0	3.3533
class Hs 3	5.8	7.7	0.1100	0.6341	0.5313	1.1290	1.0949	0.2623	0.0449	0.0053	0.0032	0	3.8151
class Hs 4	7.7	9.6	0.3237	6.4069	6.8434	5.4698	3.7251	1.1925	0.2779	0.0663	0.0209	0.0007	24.3271
class Hs 5	9.6	11.5	0.6164	7.1305	6.8358	5.0016	5.5029	3.3030	1.0469	0.2361	0.0423	0.0019	29.7175
class Hs 6	11.5	13.4	0.4682	7.9558	6.2461	2.9616	1.4780	0.6458	0.1664	0.0460	0.0025	0.0011	19.9715
class Hs 7	13.4	15.3	0.1664	4.4140	4.7241	2.7276	1.5664	0.6748	0.1687	0.0149	0.0009	0.0012	14.4591
class Hs 8	15.3	17.2	0.0317	0.8644	1.0942	0.7374	0.4882	0.2512	0.1015	0.0149	0.0007	0	3.5841
class Hs 9	17.2	19.1	0.0067	0.1100	0.1304	0.1056	0.0621	0.0370	0.0200	0.0028	0.0000	0	0.4746
class Hs 10	19.1	21	0.0018	0.0073	0.0092	0.0023	0.0019	0.0027	0.0000	0.0000	0.0000	0	0.0251
total	565364		1.72916066	27.9435617	28.1434	19.3923882	14.1251342	6.37804872	1.82662051	0.38630185	0.0703975	0.00495259	100

The peak period associated to the wave height in extreme regime is 11.5 s

ANNEXURE 3

Harbor short wave agitation (Down Times)

TABLE OF CONTENTS

1. Introduction

The aim of this annexure is to check that the berths are well protected by the designed breakwaters. In order to check it, the downtime for the two proposed berths is calculated through a numerical model which evaluates the tranquillity for the proposed port.

The wave height inside the port which makes possible that the container vessels do not interrupt the operation of loading/unloading must be limited. Different international codes have been considered as IS 4651-V: Code of Practice for Planning and Design of Ports and Harbors, PIANC guidelines and ROM 3.1-99 (Spanish Recommendations for Maritime Work). The maximum operational wave height considered for container vessels is 0.5m (forming an angle of +/- 45º over the fore and aft centerline of the vessel).

Due to the continuous raise of container traffic, the berth is expected to be expanded two or three years after finalizing the construction of Phase 1. Therefore, it has been decided not to prolong the south breakwater, beyond the berth line in order to make phase 2 and phase 3 expansions easier. Instead of that, the length of the main breakwater must be designed with the appropriate length to avoid down times.

The most important inputs parameters for the study of short wave agitation were:

- Bathymetry and dredging.
- Near shore wave data has been extracted from the offshore wave data using SWAN modeling as described in Annexure 3.
- Port layouts, geometry of the port and the length of breakwater.
- Types of breakwaters, in order to know the reflection coefficient.
- Limit of wave heights for estimation of the downtime (non operation days).

2. METHODOLOGY

The methodology used is as follows:

- The Near shore wave climate has been analyzed in order to select the cases that have been propagated into the inner port with the agitation model.
- Different meshes have been defined for the propagation. Depending on the peak period and and wave direction .
- It has been selected two areas for the proposed berths, and it has been also estimated the mean wave height in each area for each considered case.
- The downtime has been estimated for the proposed berths

3. NUMERICAL MODELS

The numerical model used has been SMC-MANOLO, it is an Advanced Model Application to Nonlinear Harbor Oscillations
Inside SMC-MANOLO Numerical Model, it has been required the use of another Wave Spectral Model (MSP). This model resolves the elliptic mild slope equation through the finite elements method. It is able to include the effect of shoaling, refraction, energy dissipation (bottom friction and wave breaking), diffraction, wave and resolve the water movement surface taking the boundary reflections.

4. SELECTED CASES OF STUDY

Near shore wave data has been extracted from the offshore wave data using SWAN modeling. Wave climate near the port has been analyzed in order to select the cases that have been propagated into the inner port with the agitation model.
The wave rose in the point of interest near the port , shows the predominant waves directions.

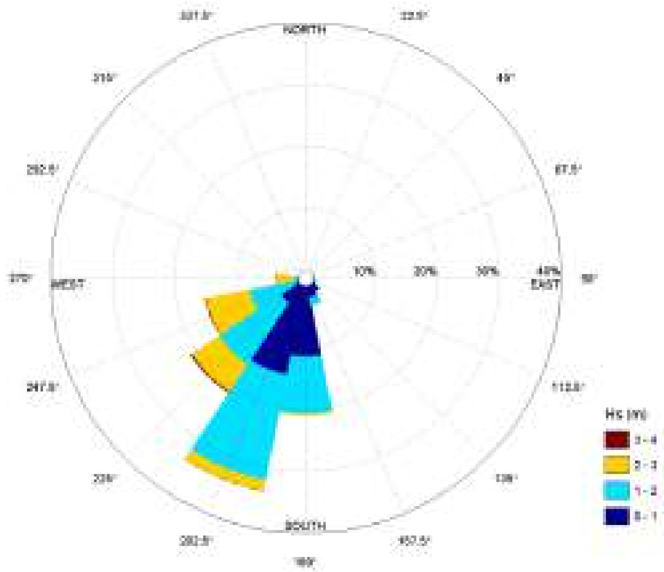


Figure 1. Wave Rose (Nearshore wave data)

The range of wave direction goes from South South-East (SSE) to the West, but the biggest probability of occurrence is South South-West.
The same information is shown in the wave rose in the occurrence table between wave height and direction.

			Hs										Probability of occurrence
			0-0.4	0.4-0.8	0.8-1.2	1.2-1.6	1.6-2	2-2.4	2.4-2.8	2.8-3.2	3.2-3.6	3.6-4	
DD	2	36.4	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
	36.4	70.8	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012
	70.8	105.2	0.193	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.198
	105.2	139.6	0.364	0.991	0.098	0.011	0.011	0.000	0.000	0.000	0.000	0.000	1.476
	139.6	174	0.012	1.581	3.312	1.301	0.187	0.004	0.000	0.000	0.000	0.000	6.397
	174	208.4	0.182	11.756	18.204	9.805	2.998	1.019	0.262	0.041	0.000	0.000	44.266
	208.4	242.8	0.094	3.715	6.133	8.097	8.258	5.668	2.109	0.456	0.146	0.072	34.748
	242.8	277.2	0.009	0.168	0.394	0.945	3.254	5.435	2.251	0.308	0.016	0.000	12.781
	277.2	311.6	0.000	0.012	0.086	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.113
	311.6	346	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
Probability of occurrence(Hs)			0.873	18.233	28.227	20.174	14.708	12.125	4.622	0.804	0.162	0.072	

The probability of occurrence in the table of directions and wave heights (Hs-DD) is concentrated in the directions between 140 º and 277º, that correspond with SSE and West. The rest of directions have a small probability of occurrence so they have not been taken in this study.

Table 1. Occurrence table (Hs-Direction)

The occurrence table for each direction gives the probability of occurrence depending on the peak period and wave height. This information has been taken for select the cases of study.

Selection Cases has been followed the next Criteria:

- Cases with high peak periods and wave height.
- Cases which have a probability of occurrence that can be relevant in the agitation study

The tables below show the probability of occurrence for each direction and red cells are the selected cases

South South-East (SSE)		T_P										
		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
H_S	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
	3.25-4.25	0	0	0	0	0	0	0	0	0	0	0
	2.25-3.25	0	0	0	0	0	0	0	0	0	0	0
	1.25-2.25	0	0	0.0135	0	0.0702	0.2624	0.0963	0.0267	0.0036	0	0
	0.25 -1.25	0	0	0.0128	0.0103	1.1108	1.0798	0.4257	0.1212	0.0324	0.0014	0
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 2. Directional Occurrence table (South South-East)

South (S)		T_P										
		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
H_S	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
	3.25-4.25	0	0	0	0	0	0	0	0	0	0	0
	2.25-3.25	0	0	0	0	0	0.0727	0.0706	0.0114	0	0.0004	0
	1.25-2.25	0	0	0	0	0.3408	2.5433	1.0160	0.4167	0.1162	0.0029	0
	0.25 -1.25	0	0	0.0014	0.0164	5.1810	6.9514	3.3835	0.5725	0.2428	0.0036	0
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 3. Directional Occurrence table (South)

South South-	T_P

West (SSW)		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
H_S	3.25-4.25	0	0	0	0	0	0	0	0.0061	0.0100	0.0014	0
	2.25-3.25	0	0	0	0.0018	0.0018	0.2809	0.2930	0.1825	0.1016	0.0093	0
	1.25-2.25	0	0	0.0096	0.0474	0.4560	3.0563	2.9518	3.1001	1.2702	0.0913	0.0018
	0.25 -1.25	0	0	0.0406	0.0635	0.8923	3.1575	9.6408	6.4287	1.6666	0.1273	0.0143
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 4. Directional Occurrence table (South South-West)

South-West (SW)		T_P										
		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
H_S	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
	3.25-4.25	0	0	0	0	0.0014	0	0	0.0467	0.0827	0.0175	0
	2.25-3.25	0	0	0	0.0292	0.0873	0.6392	0.6257	0.8852	0.5686	0.0556	0.0039
	1.25-2.25	0	0	0.0638	1.2909	1.5579	4.0341	2.3575	1.7429	0.8998	0.1233	0.0004
	0.25 -1.25	0	0	0.3875	0.1989	0.4232	0.7793	2.3711	1.2203	0.5355	0.0460	0.0046
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 5. Directional Occurrence table (South-West)

West South-West: (WSW)		T_P										
		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
H_S	3.25-4.25	0	0	0	0	0.0018	0.0014	0.0025	0.0029	0.0225	0	0
	2.25-3.25	0	0	0	0.0075	0.2043	1.8723	0.8296	0.3212	0.0902	0.0053	0
	1.25-2.25	0	0	0	0.9208	2.3204	5.8370	1.1807	0.5836	0.1540	0.0046	0
	0.25 -1.25	0	0	0.2153	0.2905	0.1155	0.0478	0.1686	0.0642	0.0139	0	0
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 6. Directional Occurrence table (West South-West)

West (W)		T_P										
		0_1	1_3	3_5	5_7	7_9	9_11	11_13	13_15	15_17	17_19	19_21
H_S	>7.25	0	0	0	0	0	0	0	0	0	0	0
	6.25-7.25	0	0	0	0	0	0	0	0	0	0	0
	5.25-6.25	0	0	0	0	0	0	0	0	0	0	0
	4.25-5.25	0	0	0	0	0	0	0	0	0	0	0
	3.25-4.25	0	0	0	0	0	0.0082	0	0	0	0	0
	2.25-3.25	0	0	0	0.0032	0.2738	1.4360	0.0998	0	0	0	0
	1.25-2.25	0	0	0	0.2150	0.2898	0.7929	0.0592	0	0	0	0
	0.25 -1.25	0	0	0.0567	0.1665	0.0356	0	0.0061	0.0053	0.0004	0	0
	0.00-0.25	0	0	0	0	0	0	0	0	0	0	0

Table 7. Directional Occurrence table (West)

5. Mesh

For obtain reliable results, this program require the use of different meshes depending on the peak period and wave direction. So it has been defined six meshes in order to propagate each case in the appropriate mesh.

Mesh 1:
This mesh has been selected for cases with peak period between 11s and 14s and directions from South to Southeast. The lowest peak period that can be simulated in this mesh is 11s so the mesh has 94.022 nodes and more than 186.500 elements.

Mesh 2 :
This mesh has been selected for cases with peak period between 8s and 10s and directions from South to Southeast. The lowest peak period that can be simulated in this mesh is 8s so the mesh has 73.672 nodes and more than 145.960 elements.

Mesh 3 :
This mesh has been selected for cases with peak period between over 15s and directions from South to Southeast. The lowest peak period that can be simulated in this mesh is 15s so the mesh has 88.252 nodes and more than 174.900 elements.

Mesh 4 :
This mesh has been selected for cases with peak period over 15s and directions from South-Southwest to West. The lowest peak period that can be simulated in this mesh is 15s so the mesh has 99.640 nodes and more than 197.379 elements.

Mesh 5 :
This mesh has been selected for cases with peak period between 11s and 14s and directions from South-Southwest to West. The lowest peak period that can be simulated in this mesh is 11s so the mesh has 87.748 nodes and more than 173.801 elements.

Mesh 6 :
This mesh has been selected for cases with peak period between 8s and 10s and directions from South-Southwest to West. The lowest peak period that can be simulated in this mesh is 9s so the mesh has 100.033nodes and more than 198.247elements.

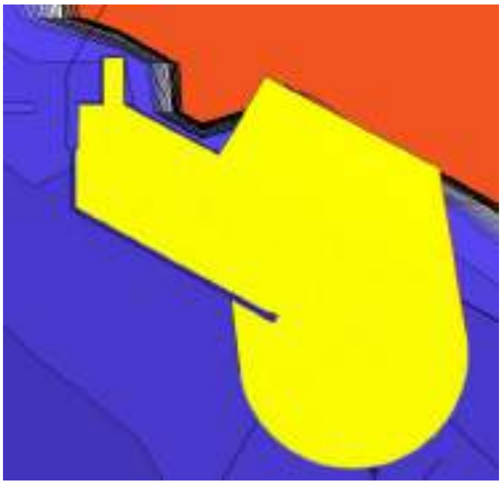


Figure 2. Mesh 1 (11s>Tp<14s) &(SSE>DD<S)

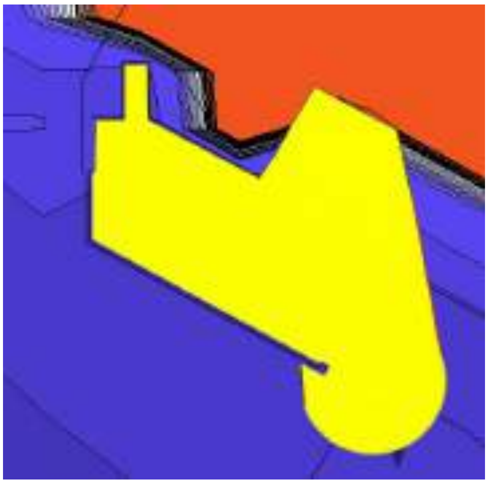


Figure 4. Mesh 2 (8s>Tp<10s) &(SSE>DD<S)

Figure 5. Mesh 3 (Tp>15s)&(SSE>DD<S)

Figure 6. Mesh 4 (Tp>15s)&(SSW >DD<W)

Figure 7. Mesh 5 (11s>Tp<14s)&(SSW >DD<W)

Figure 8. Mesh 6 (8s>Tp<10s) &(SSW >DD<W)

The boundary conditions have been selected and their reflection coefficients are listed below:

- Circular boundary. It is the boundary through which the wave conditions come into the mesh.
- Absorbing boundary, which connects the water outside the mesh with the water inside the mesh, reflection coefficient=0.
- Beach has 0.20 reflection coefficient. This is because waves suffer energy dissipation due to bottom friction and wave breaking.
- Vertical breakwater, with a reflection coefficient of 0.90.
- Rubble-Mound Breakwater, with a reflection coefficient of 0.30.

6. AREAS OF STUDY

Two areas of study have been selected for the proposed berths depending on the mooring distribution for vessels. The size of the areas has been defined depending on measures of the design vessel. It has been calculated the mean wave height in each area for each selected case

The next figure shows the areas of study:

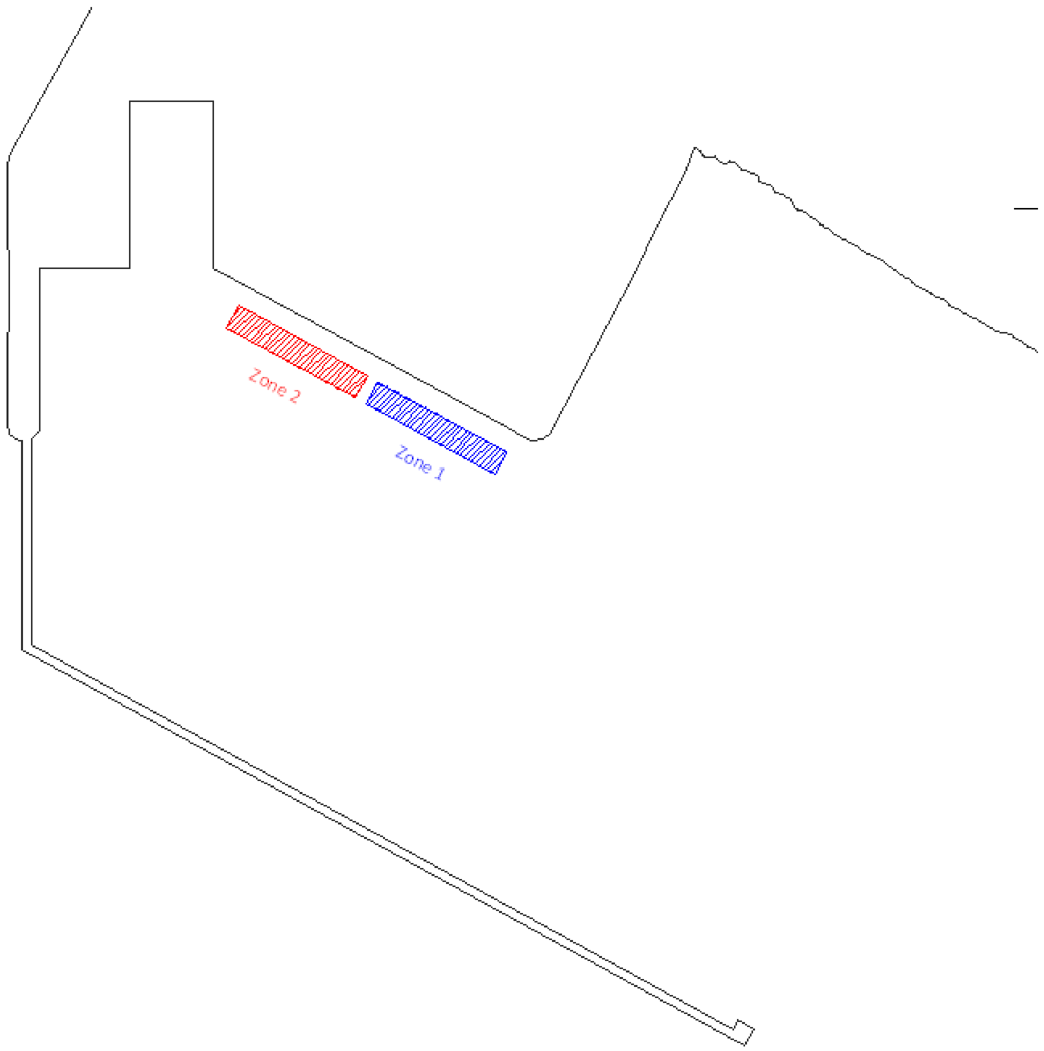


Figure 3. Areas of study (Berth line)

7. DOWNTIMES

Once the wave height has been calculated in each area for the cases under consideration, the next step is to estimate the downtime for the proposed berths.

The limiting operational wave height considered for container vessels is 0.5m (forming an angle of +/- 45º over the fore and aft centerline of the vessel) and 0.3 m in case of the wave hits crosswise, forming +/- 45 º with the transverse centre line of the vessel). These guidelines determine the maximum time period permissible for not closing the berths, which turns out to be 200 hours per year.

The next figures show that the wave direction hits the areas forming an angle of +/- 45º over the fore and aft centerline of the vessel, for this reason, the limiting operational wave height considered was Hs=0.5 m.

SSE:

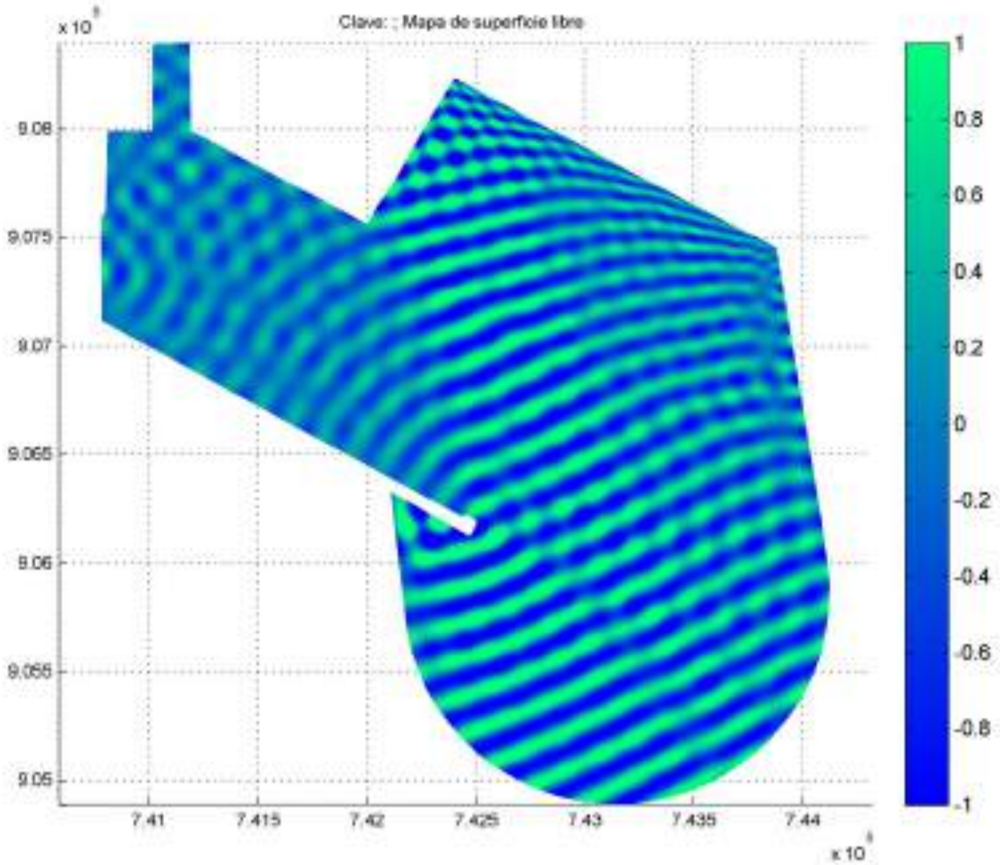


Figure 4. Water surface direction inside the port when the wave direction comes from SSE

S:

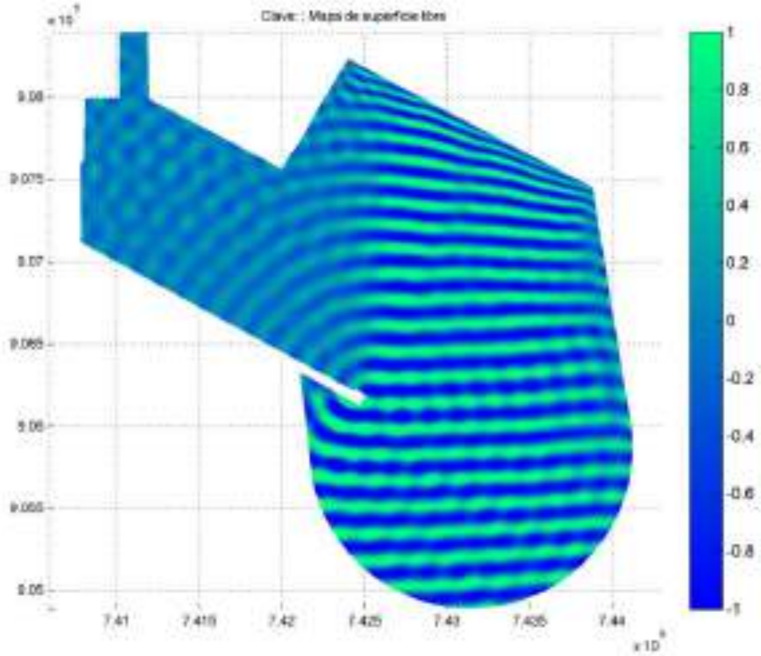


Figure 5. Water surface direction inside the port when the wave direction come from S

SW

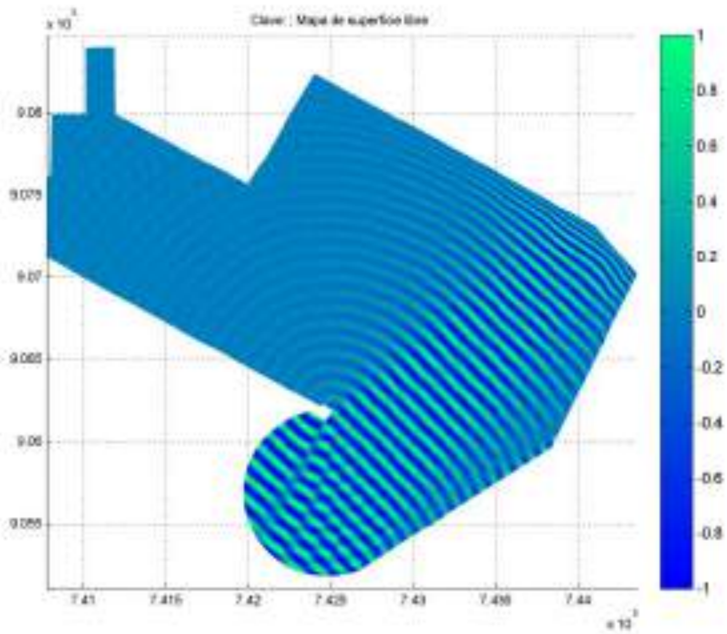


Figure 6.Water surface direction inside the port when the wave direction comes from SW

WSW

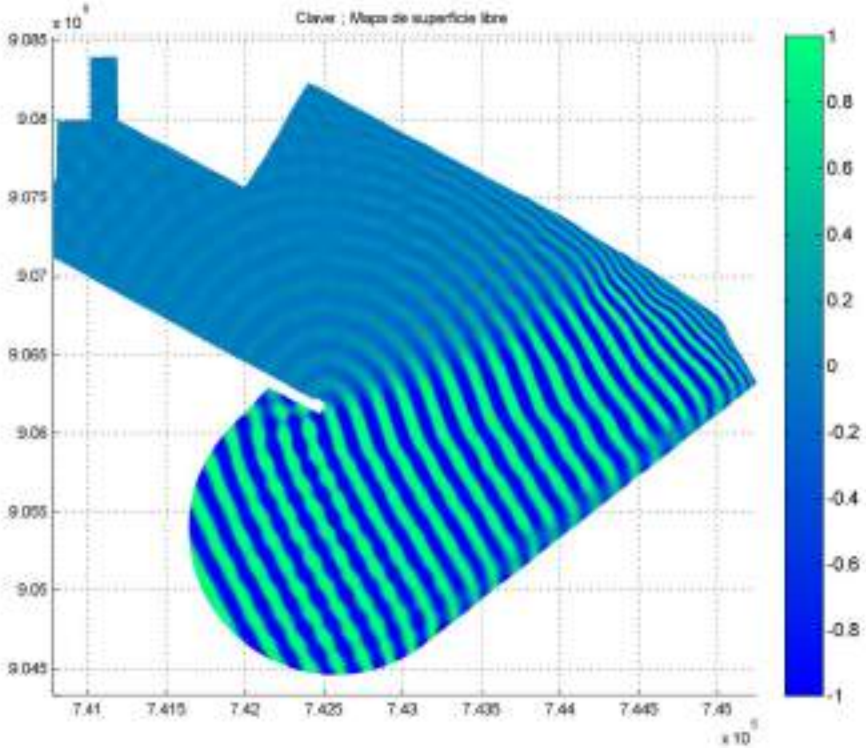


Figure 7. Water surface direction inside the port when the wave direction comeS from WSW

8. Results for the first Breakwater length study

8.1. TABLE

The table below shows the selected cases and the results of the Down Time:

HS	TP	DIRECTION		PROBABILITY OF OCCURRENCE (%)	H_{S_INSIDE} ZONE 1	Probability H_{S_INSIDE} >0.5 ZONE 1	H_{S_INSIDE} ZONE 2	Probability H_{S_INSIDE} >0.5 ZONE 2
0.66	16.67	SSE	154.6	0.0324	0.599	0.0324	0.310	
1.44	15.63	SSE	164.9	0.0036	0.5079	0.0036	0.2850	
2.05	15.63	S	169.4	0.1162	0.401		0.266	
2.21	18.52	S	170.5	0.0029	0.6394	0.0029	0.4521	
0.95	17.86	S	175.9	0.0036	0.201		0.078	
0.91	15.15	S	178.6	0.2428	0.1097		0.1090	
2.23	15.87	SSW	193.1	1.2702	0.317		0.358	
2.76	18.18	SSW	207.3	0.0093	0.4241		0.2718	
3.32	17.86	SSW	210.6	0.0014	0.499	0.0014	0.415	
3.56	15.87	SSW	212.2	0.0100	0.4665		0.4188	
2.58	15.39	SSW	212.8	0.1016	0.267		0.276	
3.92	16.39	SW	223.8	0.0827	0.2171		0.2050	
2.85	19.61	SW	228.1	0.0039	0.533	0.0039	0.384	
1	8	SSE	157.5	1.1108	0.3390		0.2638	
2	10	SSE	157.5	0.2624	0.688	0.2624	0.565	0.26238298
1	12	SSE	157.5	0.4257	0.4420		0.2929	
2	12	SSE	157.5	0.0963	0.691	0.0963	0.567	0.09625463
1	14	SSE	157.5	0.1212	0.4768		0.3033	
2	14	SSE	157.5	0.0267	0.958	0.0267	0.616	0.0267374
1	18	SSE	157.5	0.0014	0.5232	0.0014	0.3320	
2	10	S	180	2.5433	0.207		0.236	
2	12	S	180	1.0160	0.2463		0.2010	
2	14	S	180	0.4167	0.361		0.293	
3	12	WSW	247.5	0.8296	0.1243		0.1230	
3	18	WSW	247.5	0.0053	0.134		0.091	
4	16	WSW	247.5	0.0225	0.1634		0.1624	
1	10	SSE	157.5	1.0798	0.414		0.274	
1	10	S	182	6.9514	0.1012		0.1315	

HS	TP	DIRECTION		PROBABILITY OF OCCURRENCE (%)	Hs_{INSIDE}	Probability Hs_{INSIDE} >0.5	Hs_{INSIDE}	Probability Hs_{INSIDE} >0.5
					ZONE 1		ZONE 2	
1	12	S	180	3.3835	0.112		0.142	
1	14	S	175	0.5725	0.2338		0.1714	
1	16	SSW	193.1	1.6666	0.115		0.128	
1	14	SSW	207.3	6.4287	0.1881		0.1415	
1	12	SSW	210.6	9.6408	0.060		0.089	
1	10	SSW	212.2	3.1575	0.0589		0.0636	
2	10	SSW	212.8	3.0563	0.127		0.122	
2	12	SSW	202	2.9518	0.1258		0.1206	
2	14	SSW	200	3.1001	0.223		0.210	
2	10	SW	223.8	4.0341	0.1560		0.1374	
2	12	SW	228.1	2.3575	0.126		0.121	
2	14	SW	225	1.7429	0.2166		0.2121	
2	16	SW	220	0.8998	0.329		0.314	
1	12	SW	225	2.3711	0.0771		0.0543	
1	14	SW	230	1.2203	0.121		0.112	
2	12	WSW	250	1.1807	0.0402		0.0343	
3	10	WSW	246	1.8723	0.049		0.043	
2	10	W	270	0.7929	0.028		0.021	
3	10	W	270	1.4360	0.0419		0.0390	

	total%	0.4310	total%	0.3854
Down Times	days	1.5731	days	1.4066
	hours	37.756	hours	33.758

In conclusion, the berth number 1 and number 2, have a number of hours of Down Time below 200 h/year, which is the limit that recommend the different Normative which have been considered. so there will be no problem with the operability of the berths.

8.2. FIGURES

The most relevant figures (wave height and water surface) have been selected for each direction, this are the figures in which we have wave height higher than 0.5 m:

Hs	Tp	Direction	
0.66	16.67	SSE	154.58

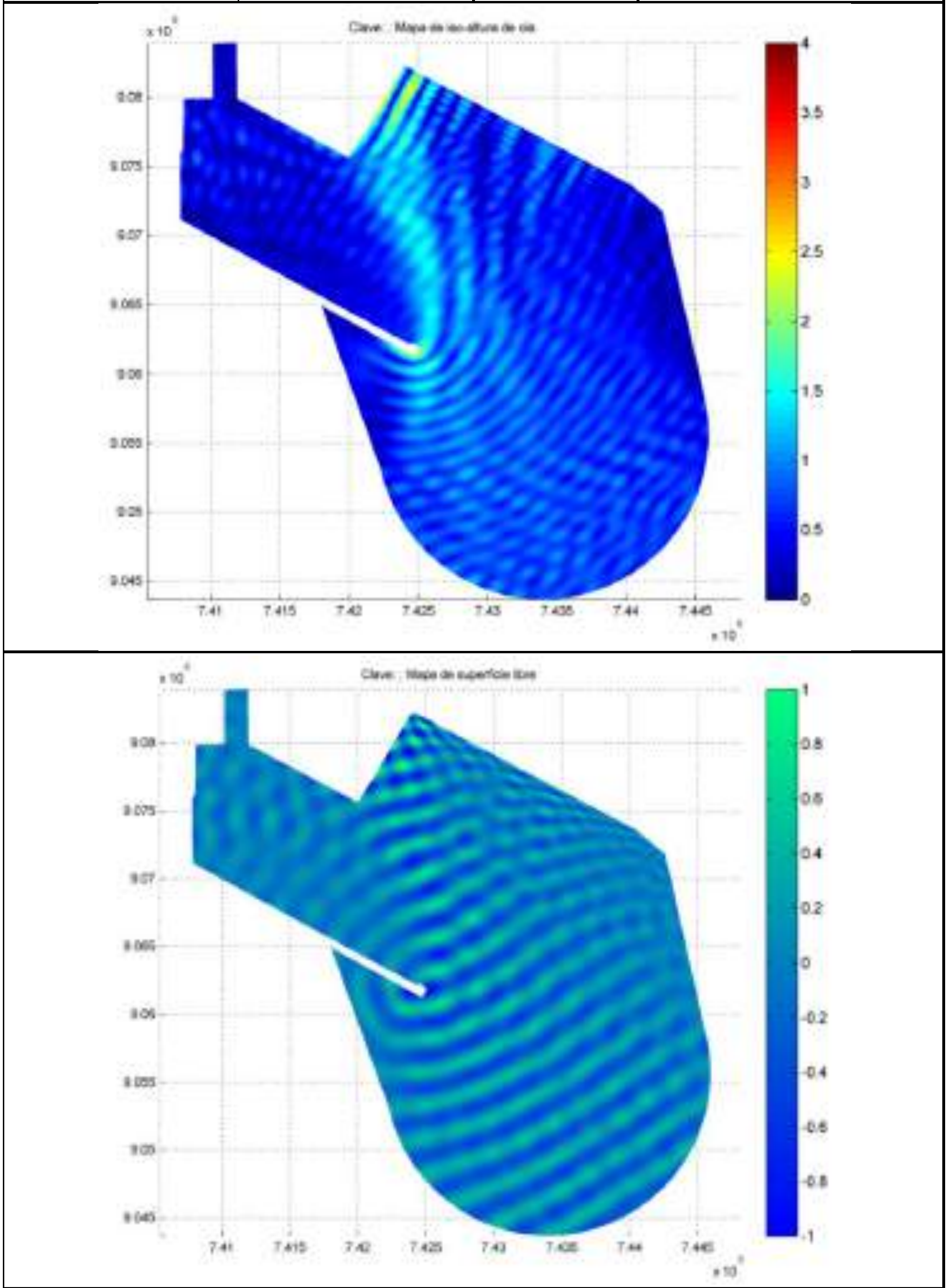
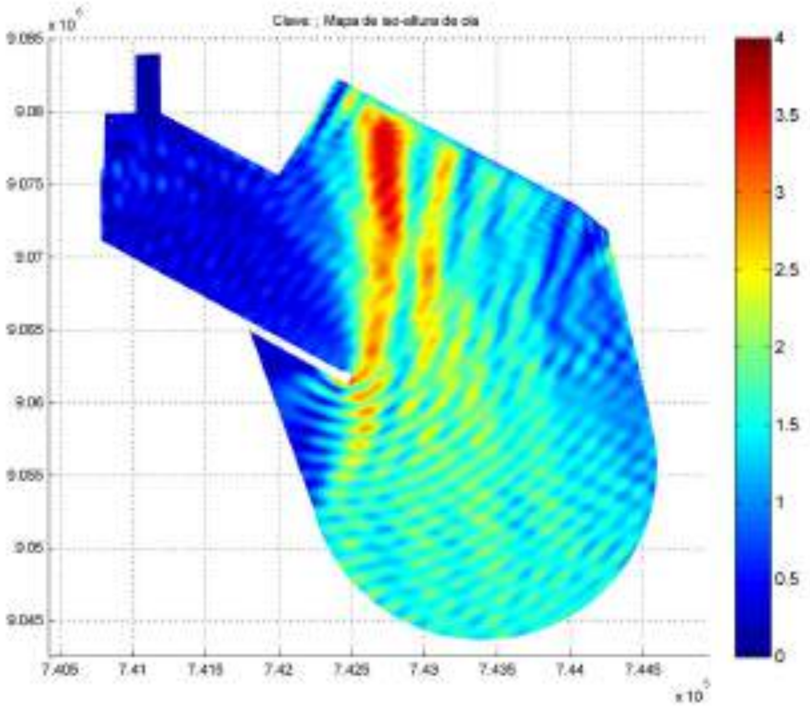


Figure 8. Maps of wave height and water surface

Hs	Tp	Direction	
1.44	15.63	SSE	164.9



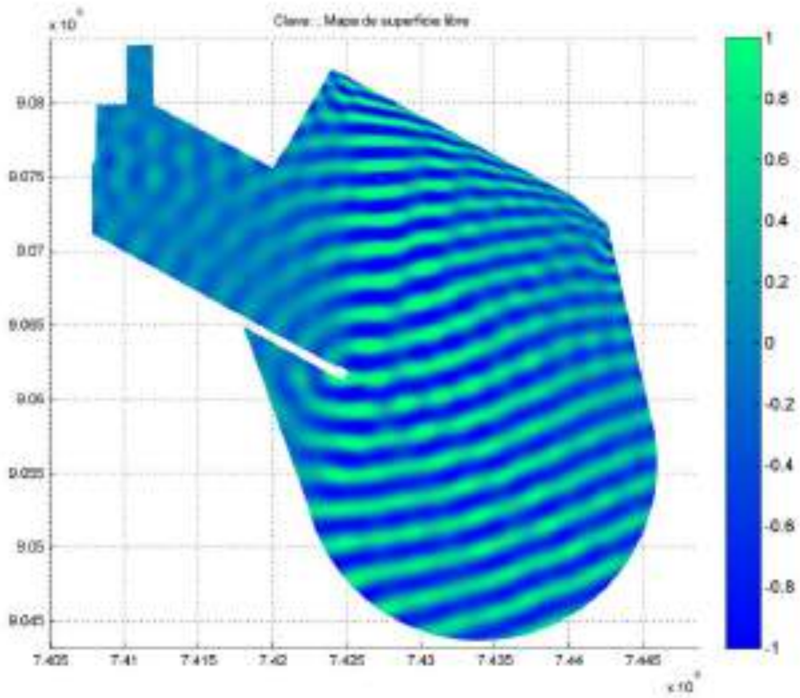
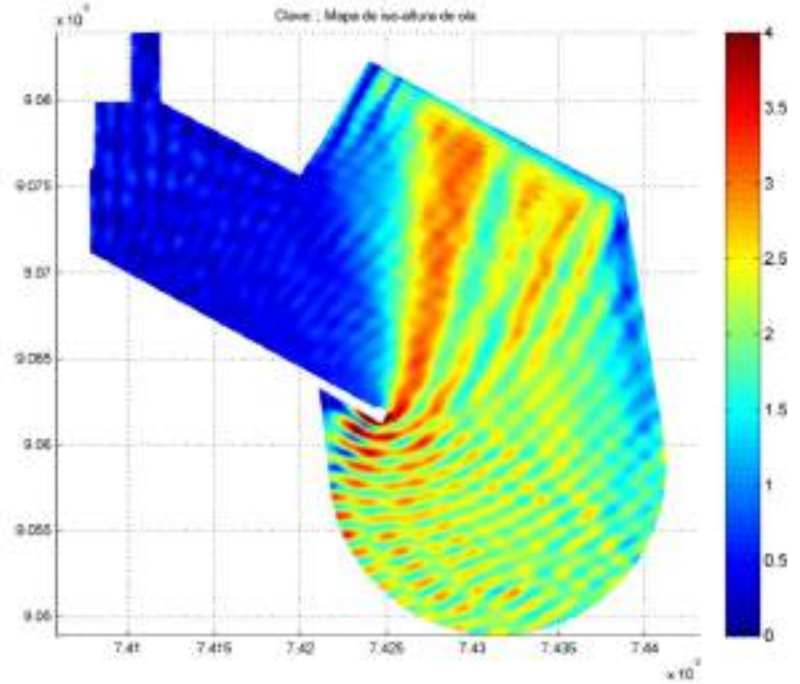


Figure 9. Maps of wave height and water surface

Hs	Tp	Direction	
2	14	S	180



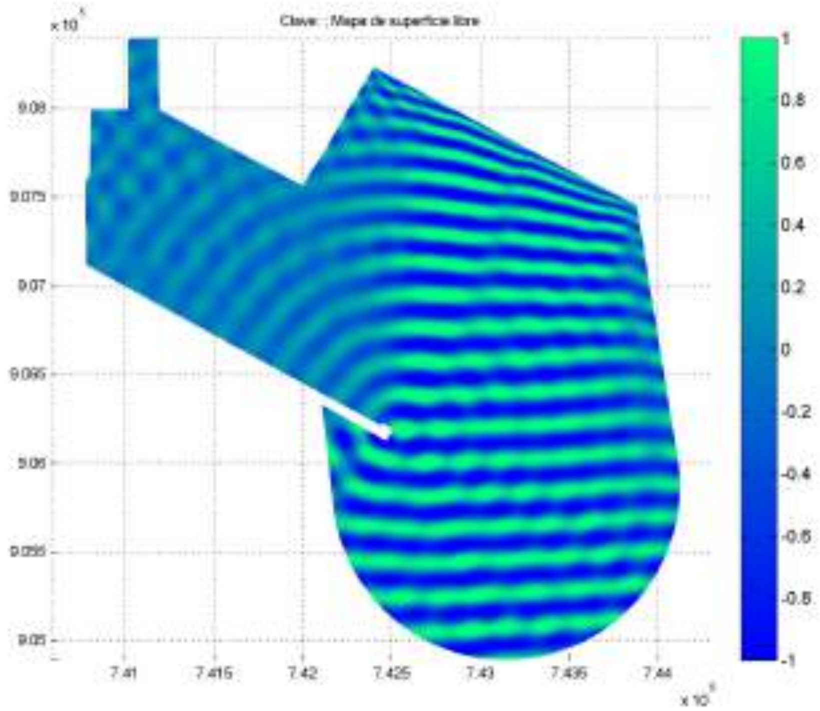
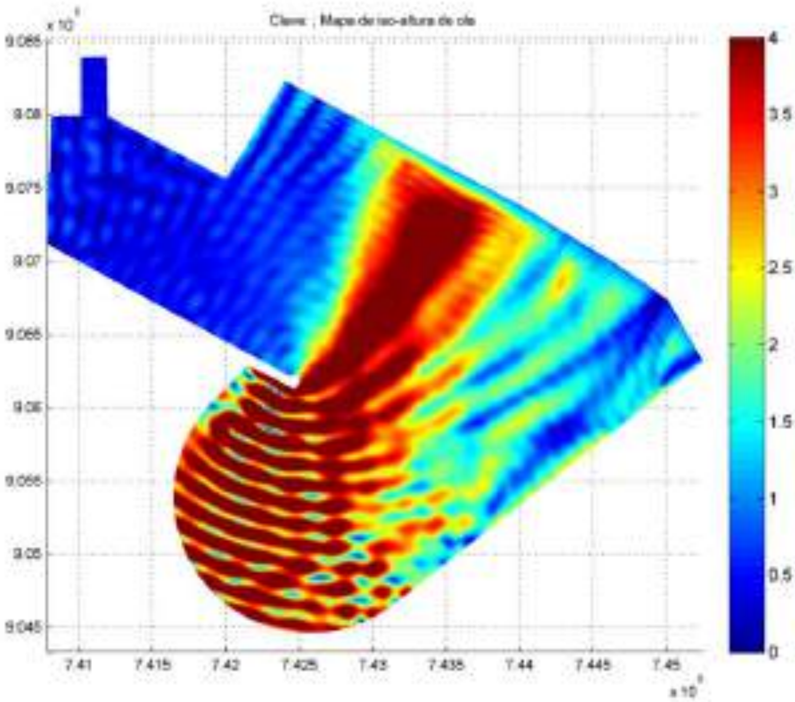


Figure 10. Maps of wave height and water surface

Hs	Tp	Direction	
3.32	17.86	SSW	210.6



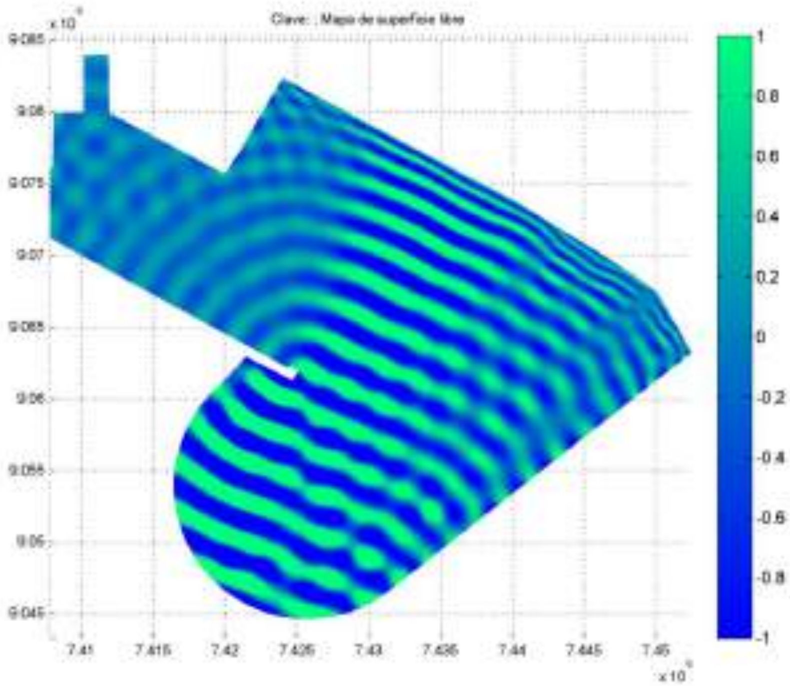


Figure 11. Maps of wave height and water surface

Hs	Tp	Direction	
2.85	19.61	SW	228.1

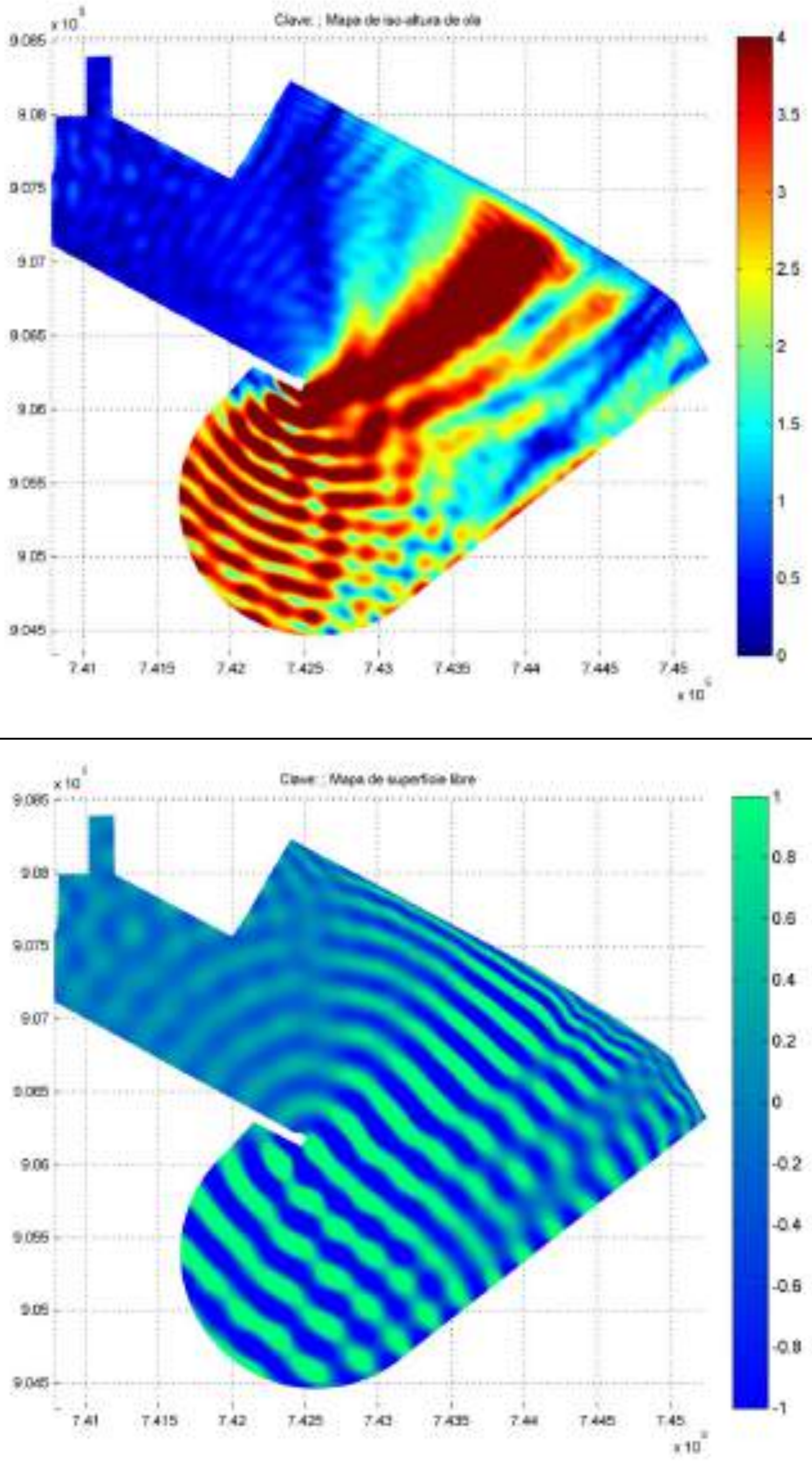
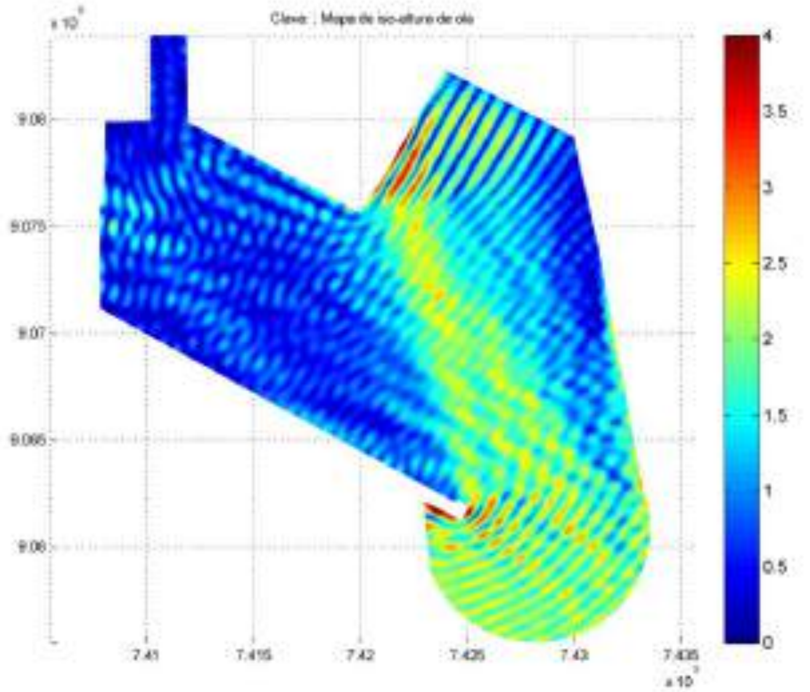


Figure 12. Maps of wave height and water surface

Hs	Tp	Direction	
2	10	SSE	157.5



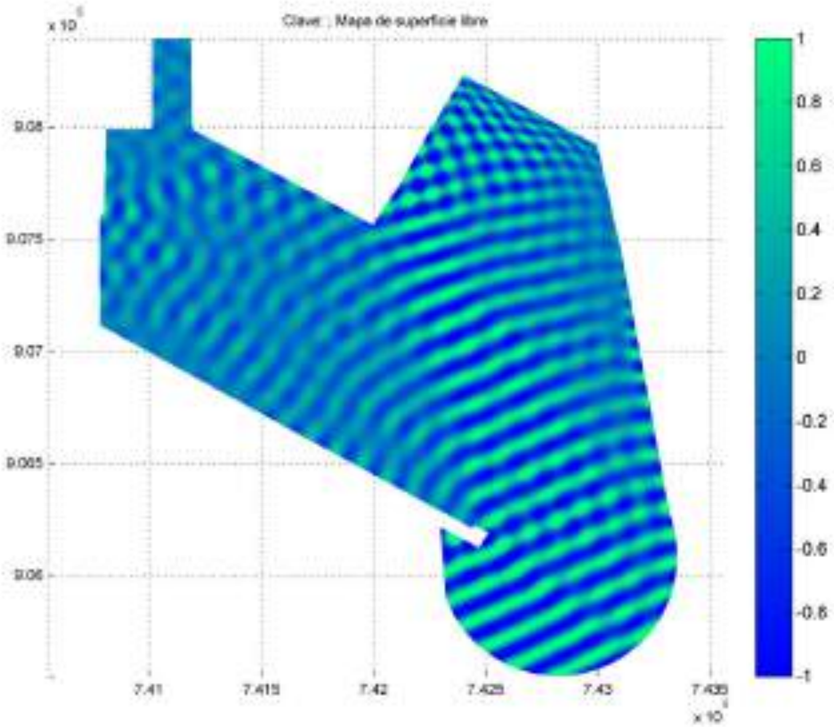
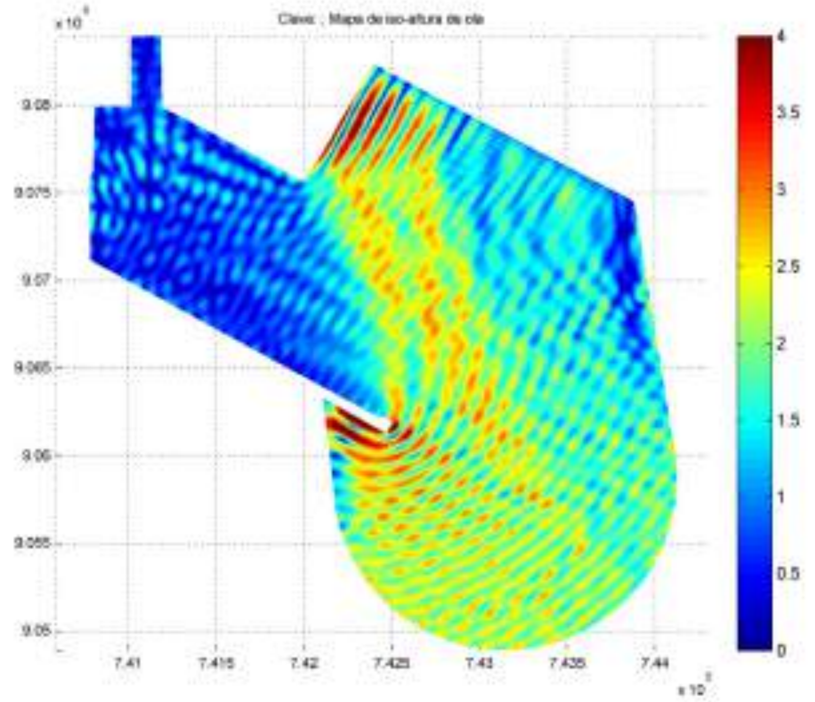


Figure 13. Maps of wave height and water surface

Hs	Tp	Direction	
2	12	SSE	157.5



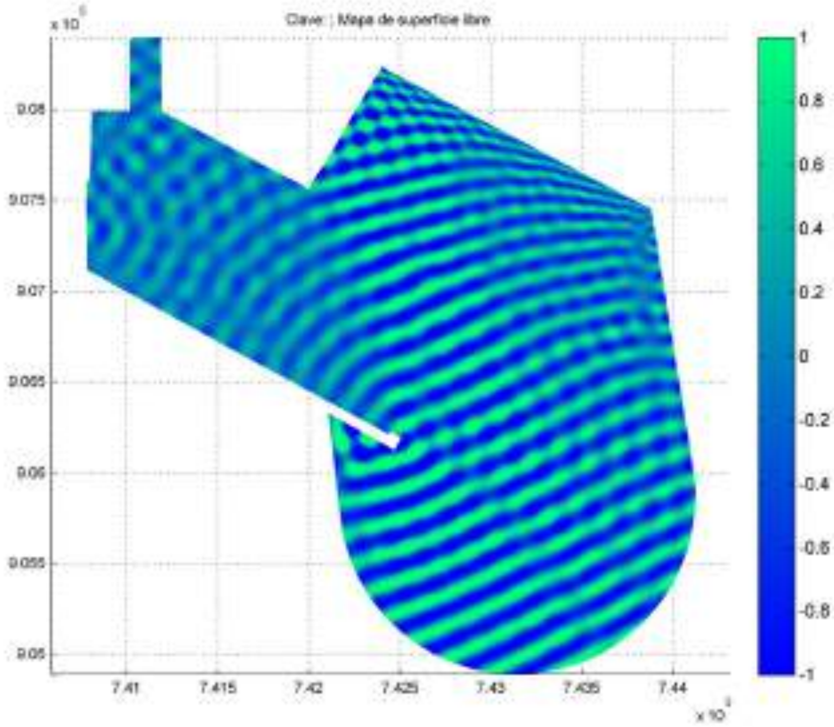
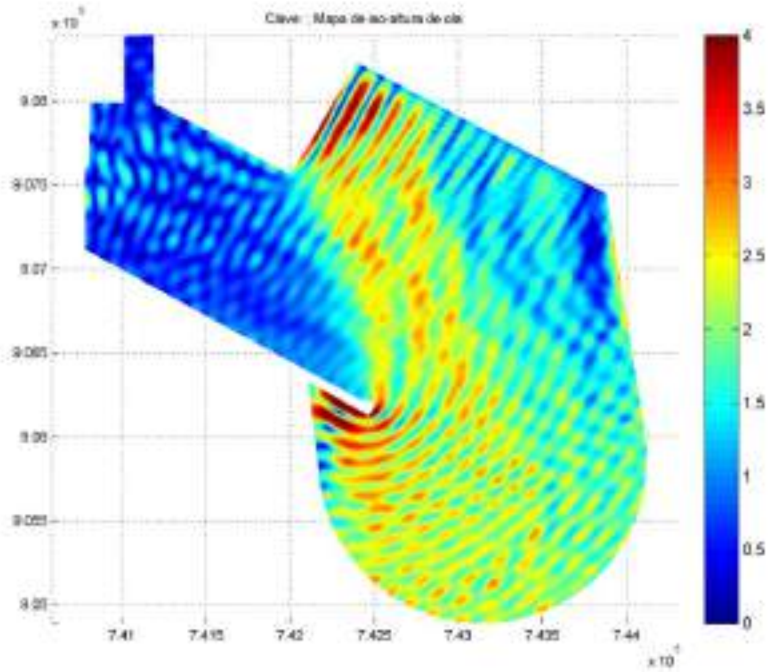


Figure 14. Maps of wave height and water surface

Hs	Tp	Direction	
2.00	14	SSE	157.5



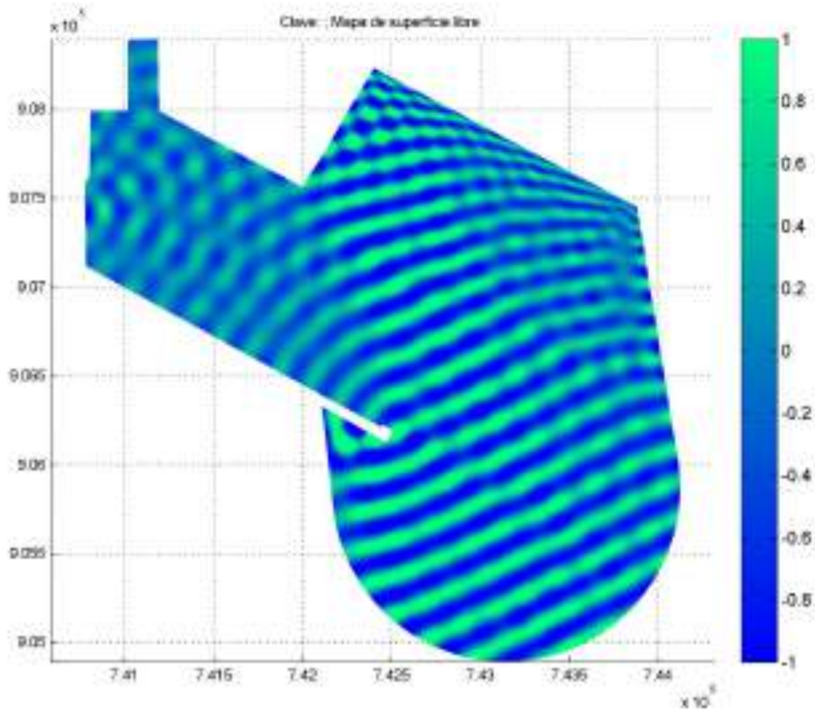
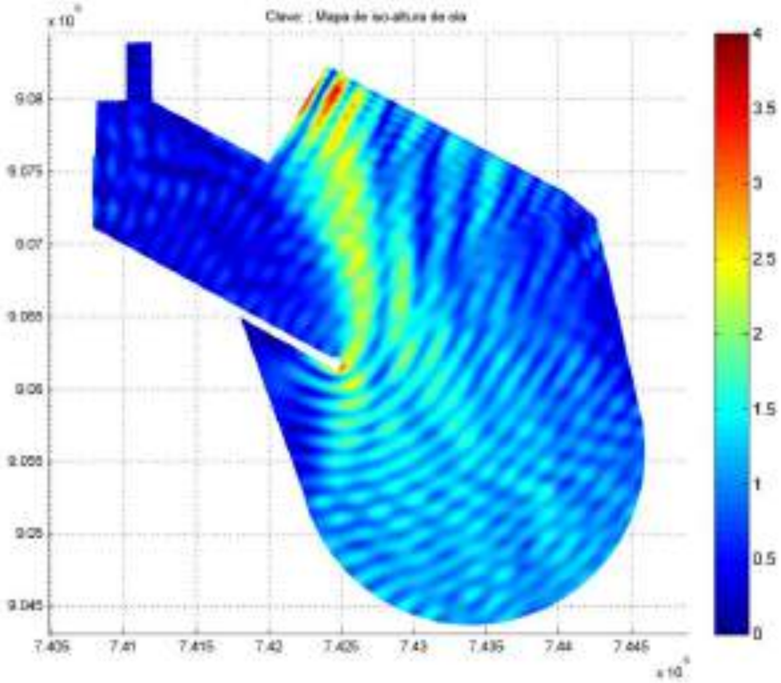


Figure 15. Maps of wave height and water surface

Hs	Tp	Direction	
1	18	SSE	157.5



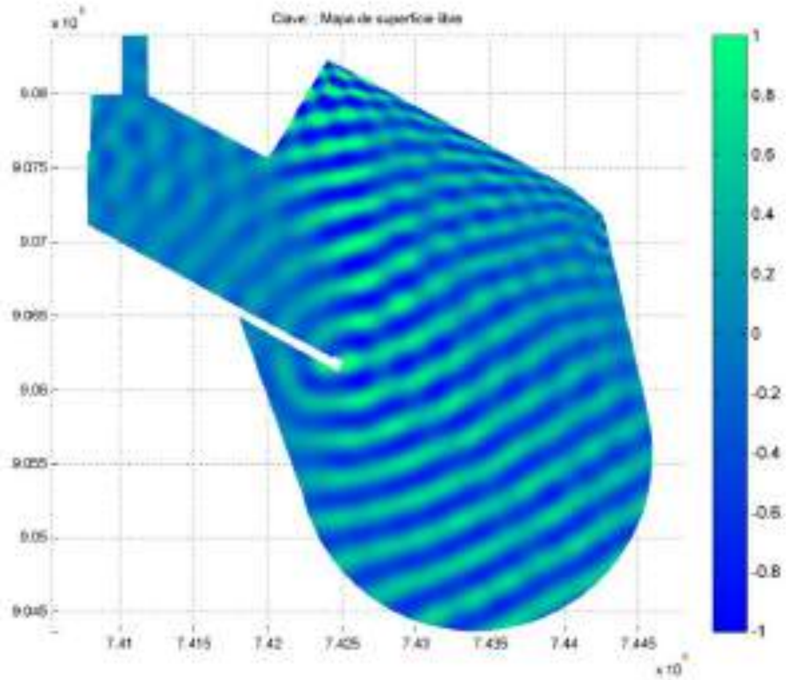


Figure 16. Maps of wave height and water surface

ANNEXURE 4

BREAKWATER DESIGN

TABLE OF CONTENTS

1. INTRODUCTION

The aim of this work is the design of the port structures (rubble-mound breakwater and vertical breakwater).
For the breakwater design have been considered 200 years of return period with 5.0 meters of wave height and a 11,5 seconds wave period.
The most important formulations have been obtained from:

- CIRIA ROCK MANUAL
- SPM (Shore Protection Manual)
- ROM
- PIANC
- CLI (Concrete Layer Innovations)
- Others

2. DATA FOR BREAKWATERS DESIGN

2.1. TIDAL LEVELS:

The tides in the region are mixed tides.

The tidal levels are shown in the table below:

HAT:	Highest Astronomical Tide. The elevation of the highest predicted astronomical tide expected to uccur. at least once a year	1.05
HHWS	Highest High Water Spring	1.04
MHHW	Mean Higher High water. The mean of the higher of the two daily high waters over a long period of time. When only one high water occurs on a day, this is taken as a higher high water .	0.83
MLHW	Mean Lower High Water. The mean of the lower of two daily high waters over a long period of time. When only one high water occurs on a day, no value is printed in the MLHW column, indicating that the tide is diurnal .	0.67
MHLW	Mean Higher Low Water. The mean of the higher of the two daily low waters over a long period of time. When only one low water occurs on a day, no value is printed in the MHLW column, indicating that the tide is diurnal .	0.41
MLLW	Mean Lower Low Water. The mean of the lower of the daily low waters over a long period of time. When only one low water occurs a day, this is taken as the lower low water	0.25
LLWS	Lowest Low Water Spring	0.02
LAT	Lowest Astronomical Tide. All heights have been taken above the lowest astronomical tide	0.00
GT	Great Diurnal Range The difference in height between mean higher high water (MHHW) and mean lower low water (MLLW).	0.58

Table 1. Tidal levels

This tidal levels have been obtained from the Databases of astronomical tide, and others heights have been add over the Highest Astronomical Tide as:

- Meteorological tide :

From the Journal of Coastal Research non-tidal sea level has been obtained. This Professional Paper based on the sea level data measured at three locations along the nearshore waters of Karnataka, west cost of India. In conclusion Correlation between alongshore component of wind and non-tidal sea level was 0.54 m at Malpe and 0.48 at Honnavar. The area of study is in the Southwest of India so approximately around 0.50m-0.54 m from storm surge have been considered.

- Expected Sea Level Rise:

Continued emission of greenhouse gases further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.
Surface temperature is projected to rise over the 21st century under all assessed emission scenarios. The Ocean will continue to warm and acidify, and global mean sea level to rise. For waterfront structures over the port design life the sea level rise for 50 years is 0.38m according to IPCC (*Intergovernmental Panel on Climate Change* , Climate Change 2014 Synthesis Report), the table below shows the projected change in global mean sea level rise for the mid and late 21st century:

		2046–2065		2081–2100	
	Scenario	Mean	*Likely* range [c]	Mean	*Likely* range [c]
Global Mean Surface Temperature Change (°C) [a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	Mean	*Likely* range [d]	Mean	*Likely* range [d]
Global Mean Sea Level Rise (m) [b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Table 2. Climate Change 2014 Synthesis Report, IPCC

The design water level for the breakwater design is=HAT+ Storm Surge (meteorological tide) + Expected sea level Rise = 1.05+0.54+0.38=1.97m

2.2. DESIGN WAVE HEIGHT

For the breakwater design, the design conditions of 1 in 200 years have been considered. The transformation wave from deep water to shallow water have been propagated to several points of interest around breakwaters areas.

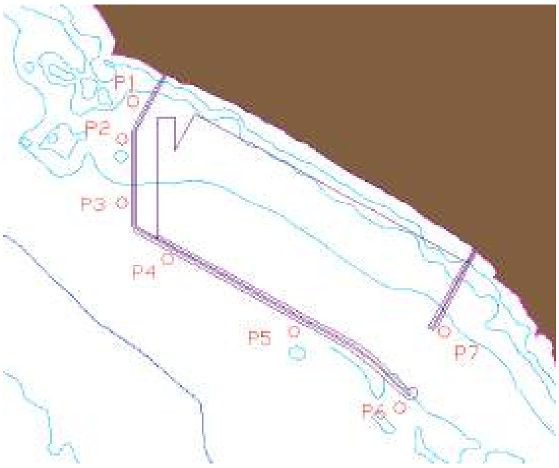


Figure 1. Situation map (Points of interest)

The result of this propagation is obtain a wave height which has been taken as the first step for the preliminary design. So mean regime and extreme regime have been estimated in each point. All values are shown in the next table:

Shallow water Points	Mean Regime	Extreme Regime (200 years)
P1	1,78	4.00
P2	2,08	5.00
P3	2,00	4.80
P4	2,02	4.50
P5	2,02	5.00
P6	2,06	4.80
P7	1,99	4.90

3. RUBBLE-MOUND BREAKWATER

3.1. ARMOR LAYER

It has been considered accropodes for the armour units and near de coastal line in shallow water cubic blocks have been considered for the armour units.(around the depth of -5m).

Hudson formula have been used for calculating the weight of armour unit:

$$W = \frac{\rho_r g H^3}{K_D \Delta^3 cot\alpha}$$

Where:

ρ_r=Mass density of Armour units

H=Design Wave Height

K_D=Stability Coefficient

$\Delta=(\frac{\rho_r}{\rho_w} - 1)^3$

ρ_w=Mass density of Water

cot α=Armour Slope (H/V)

Hudson formula for randomly placed concrete armour units has been rewritten as presented in the next equation, it has been taken from CIRIA

$$(K_D cot\alpha)^{1/3} = \frac{H_s}{\Delta D_n}$$

Using the significant wave height, Hs(m) and the nominal diameter of the unit, Dn (m).

The values of the Stability Coefficient for Accropodes is K_D =15 in the Trunk of the breakwater portion and for cubic blocks is K_D =6

Van der Meer formulas have been also considered for the design of the armour layer , these formulas are especial for accropodes: (CIRIA)

$$\frac{H_s}{\Delta D_n} = 3.7 \qquad \text{start of damage, } N_{od} = 0$$

$$\frac{H_s}{\Delta D_n} = 4.1 \qquad \text{failure, } N_{od} > 0.5$$

For the Rubble-mound breakwater design it has been taken three parts depending on the wave height:

- First Section :It is the deepest part of the rubble-mound breakwater (around the depth of -15 m to -11m),the wave height has been taken from the point of interest (P3 and P2), Hs= 5 m

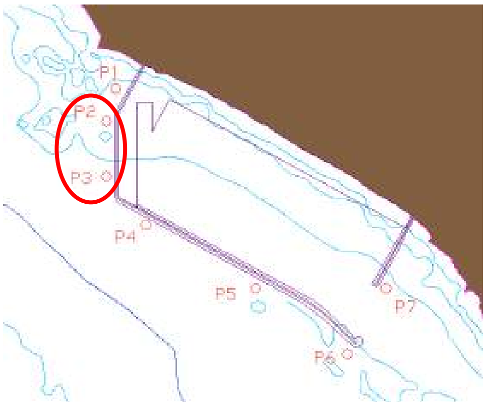


Figure 2. Situation map (Points of interest)

Accropodes as armour units have been used, the necessary volume of the armour units has been 3 m3.

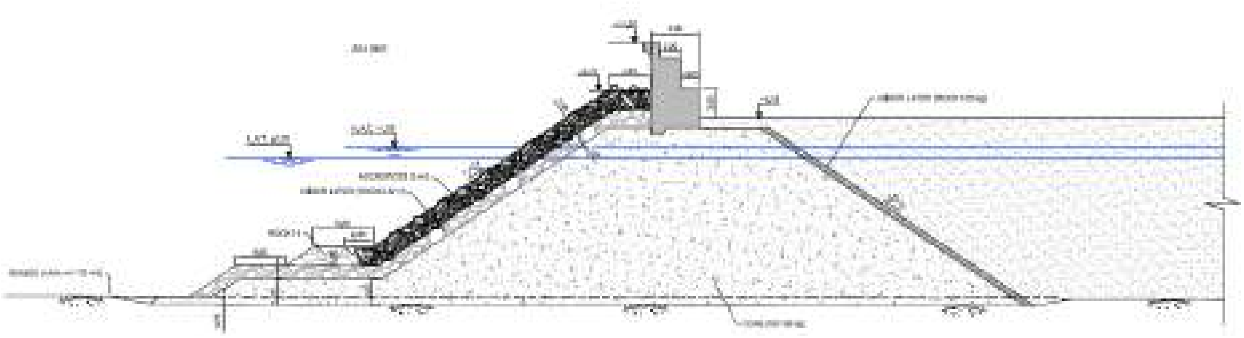


Figure 3. Rubble-mound section (Accropodes 3 m3)

- Second section, it goes between the depth from -11m to -6m, the information has been obtained from point of interest number 1 (P2) ,Hs=4 m .

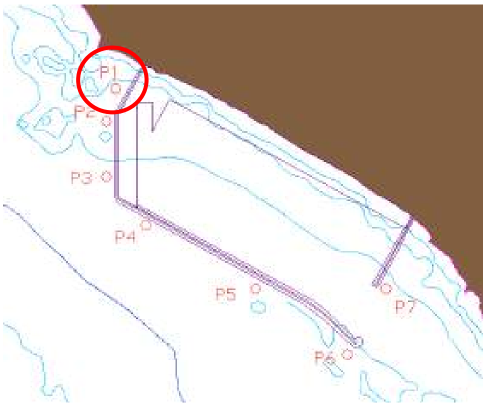


Figure 4. Situation map (Points of interest)

Accropods as armour units have been used, the necessary volume of the armour units have been 2 m3.

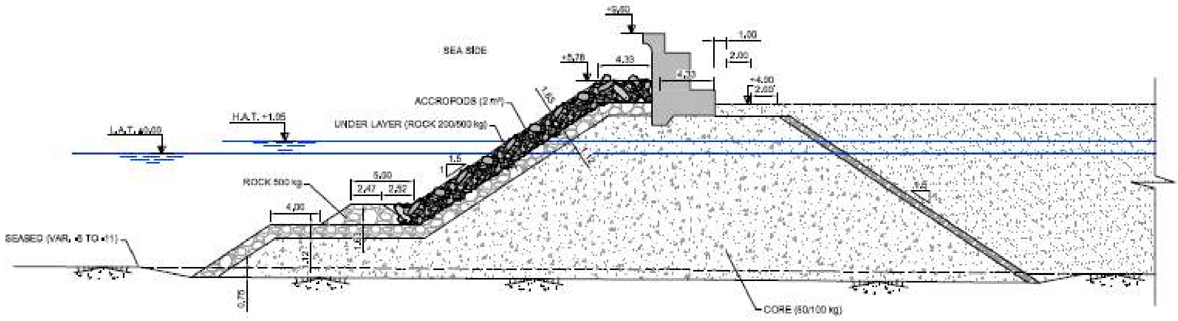


Figure 5. Rubble-mound section (Accropodes 2 m3)

- The Third Section, It goes between the depth of-6 meters to coastal line, this wave height has been obtained with an analytic method using different formulation:

  The breaking wave depth is calculated with: The formulas of Lineal Theory and Goda criteria:

$$\frac{H_b}{L_0} = 0.17\left(1 - \exp\left(\frac{-1.5\pi h_b}{L_0}\left(1 + 15\tan^{4/3}\beta\right)\right)\right)$$

The result is that a wave height of 5m breaks at the depth of -5.9 m

h	T	Lo	L1	C	k	n	Cg	Cgo	Ks	tanβ	Hlineal	Hb,goda
12.50	11.5	206.48	119.239	10.37	0.05	0.88	9.13	8.98	0.99		5.00	9.04
13.00	11.5	206.48	121.269	10.55	0.05	0.88	9.23	8.98	0.99	0.01	4.97	9.39
13.00	11.5	206.48	121.269	10.55	0.05	0.88	9.23	8.98	1.00	0.00	5.00	9.07
12.00	11.5	206.48	117.148	10.19	0.05	0.88	9.01	8.98	1.01	0.01	5.06	8.58
11.00	11.5	206.48	112.771	9.81	0.06	0.89	8.76	8.98	1.01	0.01	5.07	8.08
10.00	11.5	206.48	108.104	9.40	0.06	0.90	8.49	8.98	1.02	0.01	5.08	7.51
9.00	11.5	206.48	103.107	8.97	0.06	0.91	8.18	8.98	1.02	0.02	5.09	7.02
8.00	11.5	206.48	97.731	8.50	0.06	0.92	7.83	8.98	1.02	0.03	5.11	6.48
7.00	11.5	206.48	91.904	7.99	0.07	0.93	7.44	8.98	1.03	0.03	5.13	5.87
6.50	11.5	206.4832	88.795	7.72	0.07	0.94	7.23	8.98	1.01	0.03	5.07	5.48
6.30	11.5	206.4832	87.511	7.61	0.07	0.94	7.14	8.98	1.01	0.03	5.03	5.33
6.20	11.5	206.4832	86.859	7.55	0.07	0.94	7.09	8.98	1.00	0.03	5.02	5.25
6.10	11.5	206.4832	86.201	7.50	0.07	0.94	7.04	8.98	1.00	0.03	5.02	5.17
6.05	11.5	206.4832	85.870	7.47	0.07	0.94	7.02	8.98	1.00	0.03	5.01	5.13
6.00	11.5	206.4832	85.537	7.44	0.07	0.94	7.00	8.98	1.00	0.03	5.01	5.09
5.95	11.5	206.4832	85.202	7.41	0.07	0.94	6.97	8.98	1.00	0.03	5.01	5.05
5.9	11.5	206.48	84.865	7.38	0.07	0.94	6.95	8.98	1.00	0.03	**5.01**	**5.01**

Once the wave height has broken, formulas from Dally et al (1985) have been used to calculate the wave height in different points near the coastal line:

$$\frac{H}{H_b} = \left[\left(\frac{h}{h_b} \right)^r (1+\alpha) - \alpha \left(\frac{h}{h_b} \right)^2 \right]^{1/2}$$

$$\alpha = \frac{K \gamma_s^2}{\tan\beta \left(\frac{5}{2} - \frac{K}{\tan\beta} \right)} \left(\frac{h}{H} \right)_b^2 ; \; r = \frac{K}{\tan\beta} - \frac{1}{2}$$

Slope	K	γs
1 / 80	0.100	0.350
1 / 65	0.115	0.355
1 / 30	0.275	0.475

At the depth of -5 m the wave height is 3.3 m, this has been taken for the rubble-mound breakwater design in the part near the coastal line using cubic blocks as armour units.

h	L	tan β	K	YS	r	α	h	hb	Hb	H
5.9	23.379	0.0300	0.275	0.475	8.67	-0.43	5.9	5.9	5.01	5.0086
5.8	22.225	0.0300	0.275	0.475	8.67	-0.43	5.8	5.9	5.015	4.7757
5.75	21.622	0.0300	0.275	0.475	8.67	-0.43	5.75	5.9	5.015	4.6619
5.7	21.000	0.0300	0.275	0.475	8.67	-0.43	5.7	5.9	5.015	4.5519
5.65	20.358	0.0300	0.275	0.475	8.67	-0.43	5.65	5.9	5.015	4.4453
5.6	19.694	0.0300	0.275	0.475	8.67	-0.43	5.6	5.9	5.015	4.3423
5.55	19.004	0.0300	0.275	0.475	8.67	-0.43	5.55	5.9	5.015	4.2427
5.5	18.287	0.0300	0.275	0.475	8.67	-0.43	5.5	5.9	5.015	4.1463
5.45	17.538	0.0300	0.275	0.475	8.67	-0.43	5.45	5.9	5.015	4.0531
5.4	16.754	0.0300	0.275	0.475	8.67	-0.43	5.4	5.9	5.015	3.9631
5.35	15.930	0.0300	0.275	0.475	8.67	-0.43	5.35	5.9	5.015	3.8760
5.3	15.058	0.0300	0.275	0.475	8.67	-0.43	5.3	5.9	5.015	3.7918
5.25	14.130	0.0300	0.275	0.475	8.67	-0.43	5.25	5.9	5.015	3.7105
5.2	13.135	0.0300	0.275	0.475	8.67	-0.43	5.2	5.9	5.015	3.6318
5.15	12.054	0.0300	0.275	0.475	8.67	-0.43	5.15	5.9	5.015	3.5559
5.1	10.864	0.0300	0.275	0.475	8.67	-0.43	5.1	5.9	5.015	3.4824
5.05	9.523	0.0300	0.275	0.475	8.67	-0.43	5.05	5.9	5.015	3.4114
5	7.955	0.0300	0.275	0.475	8.67	-0.43	5	5.9	5.015	3.3427

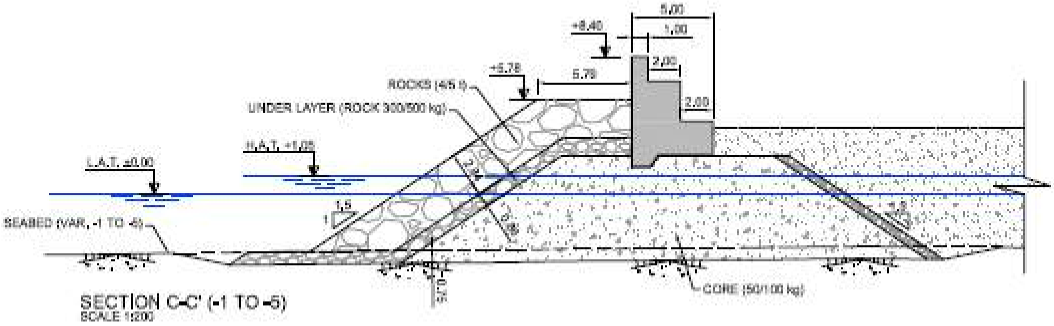
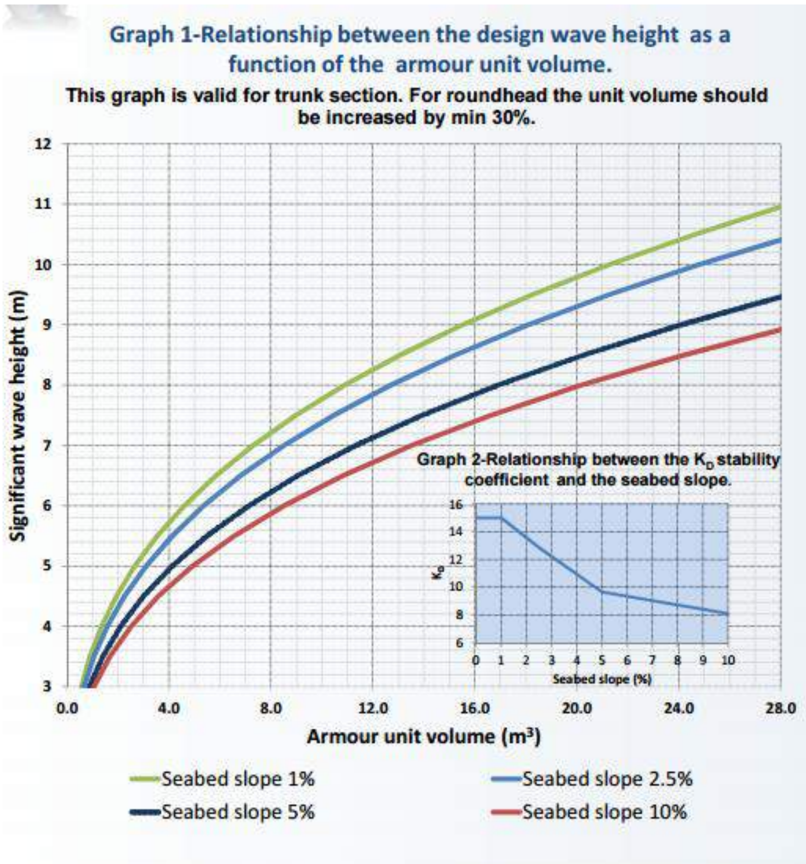


Figure 6. Rubble-mound section (Cubic Blocks)

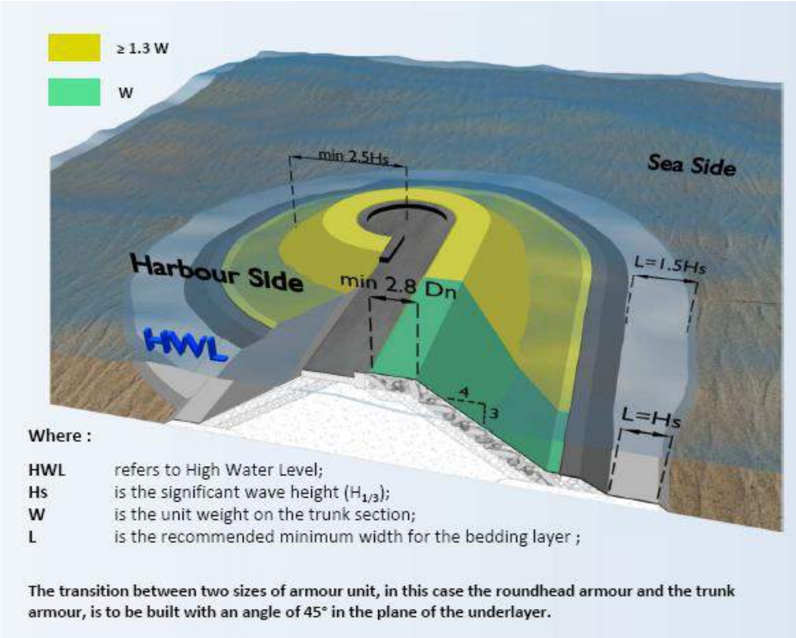
A way of checking about the Volume of the Accropodes which have been calculated , CLI has a graph, which shows the relationship between the Significant wave Height as a function of the armour unit volume. The sea bed slope that has been considered is 1%.



Specific data as the armour Layer Thickness has been obtained from CLI:
The armour layer thickness is a theoretical value obtained by multiplying D_n by the thickness coefficient (K_t). The following K_t values are applicable for the different CLI concrete units for accropodes.

Kt=1.29

Some dimensions or the design have been considered from CLI



And others dimensions have been obtained from Iribarren Formula as the height of crest:
The armour Units height crest is 1.50*Hd. and the Crown height crest is 0.75*Hd

a) Cota de coronación del espaldón = 1,50 x H_0 medido sobre la cota de la PMVE (pleamar máxima viva equinoccial).

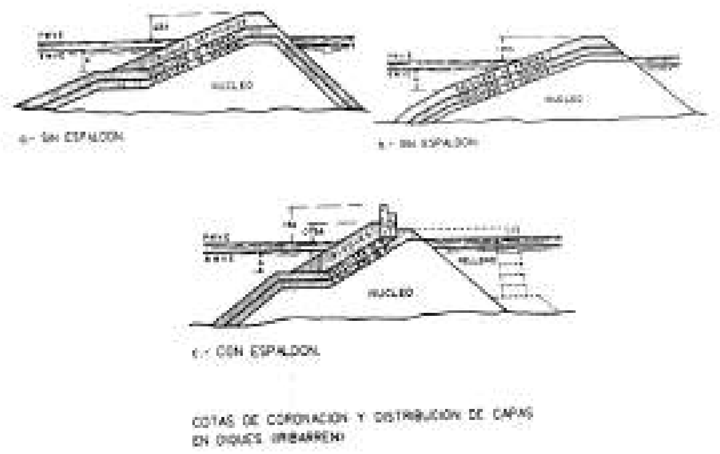


Figura 3. Criterio geométrico de un dique en talud. Teoría de Iribarren

3.2. UNDER LAYER

For this layer a scale of weight have been taken between W(Armor Layer)/10 and W(Armor Layer)/20.
And the width have been calculated with the value of D50, considering two layers.

3.3. CORE

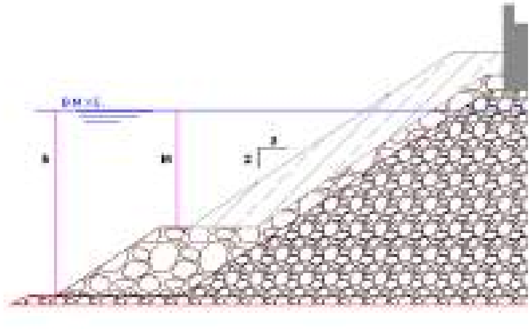
The Weight of the Core have to be between 50 kg to 100 kg, and also considering the scale between W(Under Layer)/10 and W(Under Layer)/20.

3.4. WINDWARD TOE PROTECTION

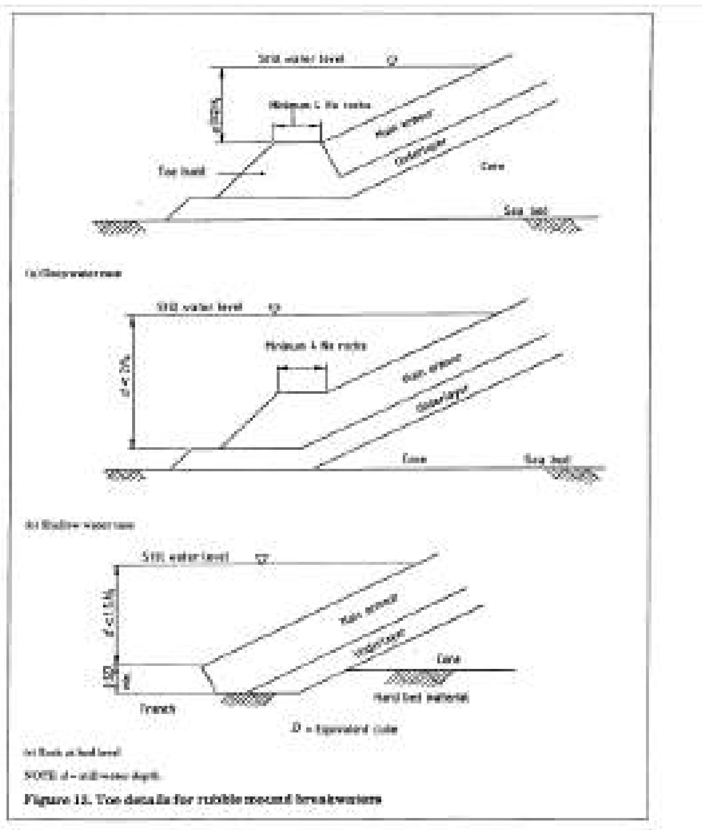
Toe protection to sloping rock armour layer (front face of rockfill structures) (CIRIA).
Sometimes a stability relationship between Hs/(ΔDn50) and ht/Hs is assumed, indicating that a lower value of ht/Hs (higher toe) should give more damage.

Stability of toe protection

h_t/ h_s	H_S/ AD_{n50}
0.5	3.3
0.6	4.5
0.7	5.4
0.8	6.5



For the width of the toe protection 3-4 D_{n50} have been considered



Criterios geométricos de cimentación siguiendo la BSI, Part VII

4. VERTICAL BREAKWATER

The design of the vertical breakwater have been calculated considering the strengths of wave, in compliance with all safety coefficients that are explained in the ROM 0.5-05 code.

Different heights of crest have been considered depending on the possibility of the overtopping. The vertical sections which in Phase 2 and phase 3 will have container layer in the port side, any overtopped could be possible.
However the rest of the vertical sections which will have water in the side port , a small overtopped could be allow.

4.1. WAVE PRESSURE FORMULAS

The pressures which hit the vertical breakwater due to the dynamic wave action has been obtained using Takahashi formulas and Goda formulas. These pressures are shown in the pressures diagram below. These are the forces together with the uplift pressures and the own weight of the structure which determine the geometry of the vertical breakwater. For the final result the geometry of the vertical breakwater has to satisfy with safety coefficients as sliding safety coefficient (S.S.C.) and roll-over safety coefficient (R.S.C.)

4.1.1. TAKAHASHI FORMULAS

$$\delta_{11} = 0.93\left(\frac{A_b}{L} - 0.12\right) + 0.36\left(\frac{h-d}{h} - 0.6\right)$$

$$\delta_{22} = -0.36\left(\frac{A_b}{L} - 0.12\right) + 0.93\left(\frac{h-d}{h} - 0.6\right)$$

$$\alpha_{I1} = \begin{cases} \dfrac{\cosh(\delta_2)}{\cosh(\delta_1)} \rightarrow \text{si} \rightarrow \delta_2 \leq 0 \\ \dfrac{1}{\cosh(\delta_1)\sqrt{\cosh(\delta_2)}} \rightarrow \text{si} \rightarrow \delta_2 > 0 \end{cases}$$

$$\delta_1 = \begin{cases} 20 \cdot \delta_{11} \rightarrow \delta_{11} \leq 0 \\ 15 \cdot \delta_{11} \rightarrow \delta_{11} > 0 \end{cases}$$

$$\alpha_{I0} = \begin{cases} \dfrac{H_D}{d} \rightarrow \text{si} \rightarrow H_D \leq 2 \cdot h_t \\ 2.0 \rightarrow \text{si} \rightarrow H_d > 2 \cdot h_t \end{cases}$$

$$\delta_2 = \begin{cases} 4.9 \cdot \delta_{22} \rightarrow \delta_{22} \leq 0 \\ 3.0 \cdot \delta_{22} \rightarrow \delta_{22} > 0 \end{cases}$$

$$\alpha_I = \alpha_{I1} \cdot \alpha_{I0}$$

$$\alpha_2^{\ *} = \max\{\alpha_{2Goda}, \alpha_I\} \rightarrow \alpha_I = \alpha_{I0}\alpha_{I1}$$

Takahashi pressure:

$$\eta^* = 0.75 \cdot [1 + \cos(\beta)]\lambda_1 \cdot H_D$$

$$P_1 = 0.50 \cdot [1 + \cos(\beta)] \cdot [\lambda_1\alpha_1 + \lambda_2\alpha^*{}_2 \cos^2(\beta)]\gamma_w H_D$$

$$P_2 = \frac{P_1}{\cosh\left(\dfrac{2\pi h}{L}\right)}$$

$$P_3 = \alpha_3 P_1$$

$$P_u = 0.50 \cdot [1 + \cos(\beta)]\lambda_3\alpha_1\alpha_3\gamma_w H_D$$

$$\lambda_1 = \lambda_2 = \lambda_3 = 1$$

4.1.2. GODA FORMULAS

$$\alpha_1 = 0.6 + \frac{1}{2}\left[\frac{\frac{4\pi h}{L}}{senh\left(\frac{4\pi h}{L}\right)}\right]^2 \qquad \alpha_2 = mín\left\{\left(\frac{h_b - d}{3h_b}\right)\frac{H_D{}^2}{d^2}, \frac{2d}{H_d}\right\} \qquad \alpha_3 = 1 - \frac{h'}{h}\left[1 - \frac{1}{coh\left(\frac{2\pi h}{L}\right)}\right]$$

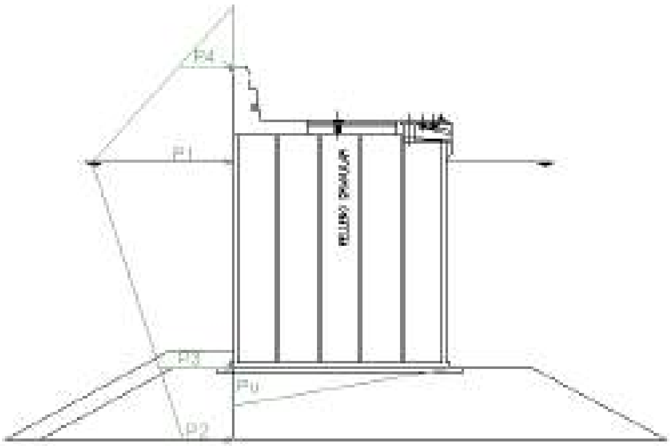
$$\eta^* = 0.75[1 + \cos\beta]H_D$$

$$P_1 = 0.50[1 + \cos(\beta)][\alpha_1 + \alpha_2 \cos^2(\beta)]\gamma_w H_D \qquad P_2 = \frac{P_1}{\cosh\left(\frac{2\pi h}{L}\right)} \qquad P_3 = \alpha_3 P_1$$

$$P_4 = P_1\left(1 - \frac{h_c}{\eta^*}\right) \rightarrow si\ \eta^* > h_c$$

$$P_4 = 0 \rightarrow si\ \eta^* < h_c$$

$$h^*_c = \min\{\eta^*; h_c\}$$



4.2. SAFETY COEFFICIENTS

THE METHODOLOGY OF THE ROM 0.5-05 have been followed in order to calculate the sliding safety coefficient (S.S.C.) and roll-over safety coefficient (R.S.C.)

$$SSC = \frac{\mu V}{H}$$

$$RSC = \frac{M_E}{M_V}$$

4.3. RUBBLE MOUND FOUNDATION

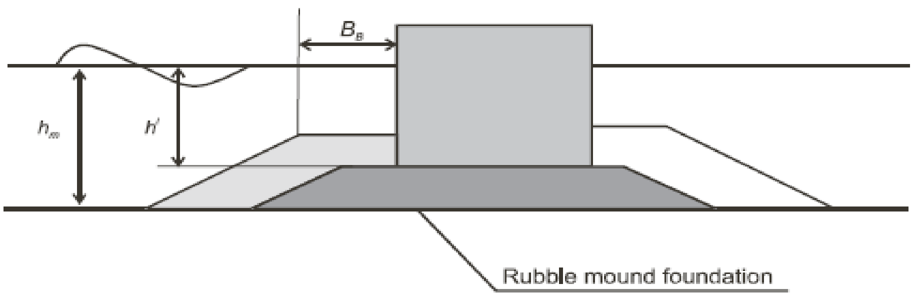
Toe protection to caisson or vertical wall breakwaters

The presence of vertical structures leads to an amplification of near-bed water particle velocities, due to wave reflection. Design of a rubble protection in front of such a structure therefore requires lower toe stability numbers Ns = Hs/(ΔDn50) than needed for a sloping rubble face.

$$\frac{H_s}{\Delta D_{n50}} = \max\left\{1.8\,,\ 1.3a\frac{h'}{H_s} + 1.8\exp\left(-1.5a(1-\kappa)\frac{h'}{H_s}\right)\right\}$$

where:

a	=	$(1-\kappa)/\kappa^{1/3}$ (-)
κ	=	$\kappa_1\ \kappa_2$ (-)
κ_1	=	$2kh'/\sinh(2kh')$ (-)
κ_2	=	$\max\{0.45\sin^2\beta\ \cos^2(kB_B\cos\beta),\ \cos^2\beta\ \sin^2(kB_B\cos\beta)\}$ (-)
k	=	wave number (-); $k = 2\pi/L_p$ (-)
h'	=	depth of the berm underlayer (m)
B_B	=	berm width (m)
β	=	angle of wave incidence (°); for head-on: $\beta = 0°$.



4.4. TOE PROTECTION:

$$N_s = \frac{H_s}{\Delta D_{n50}} = \left(5.8\frac{h_b}{h_s} - 0.6\right) N_{od}^{\ 0.19}$$

$$\Delta = \left(\frac{\gamma}{\gamma_w}\right) - 1$$

h_b=depth of the top of the toe protection

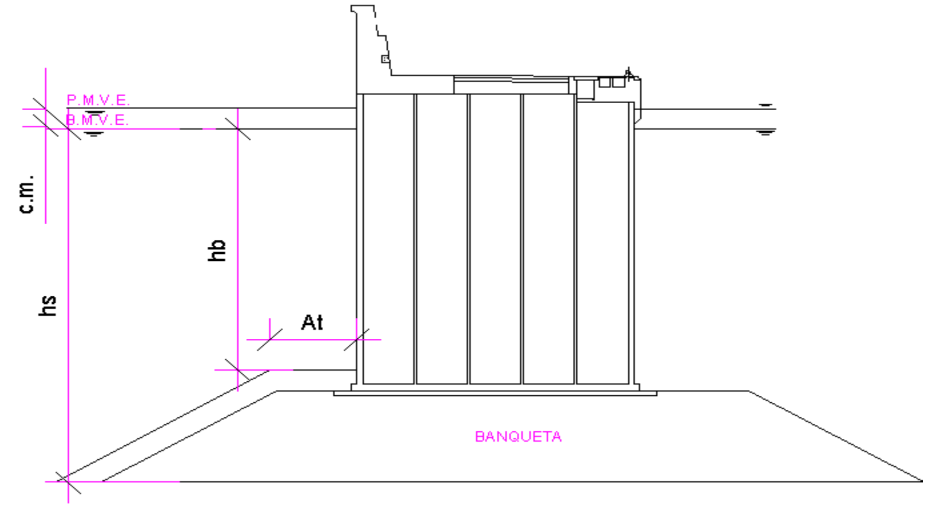
h_s= depth of the bottom of the toe protection

The values of the damage number, *Nod*, to be used are as follows:

$$N_{od} = \begin{Bmatrix} 0.5 \\ 2 \\ 5 \end{Bmatrix}$$

almost no damage
acceptable damage
failure

$$W = \gamma \cdot \left(\frac{H_S}{\Delta N_S}\right)^3$$



4.5. VERTICAL BREAKWATER SECTION

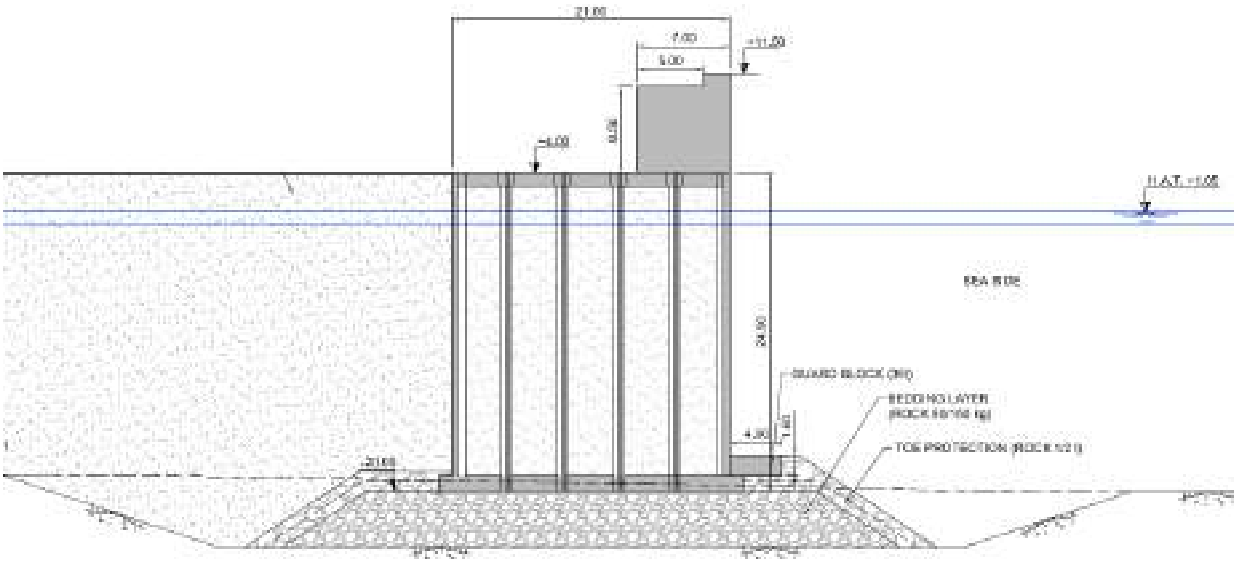


Figure 7. No overtopped Vertical section

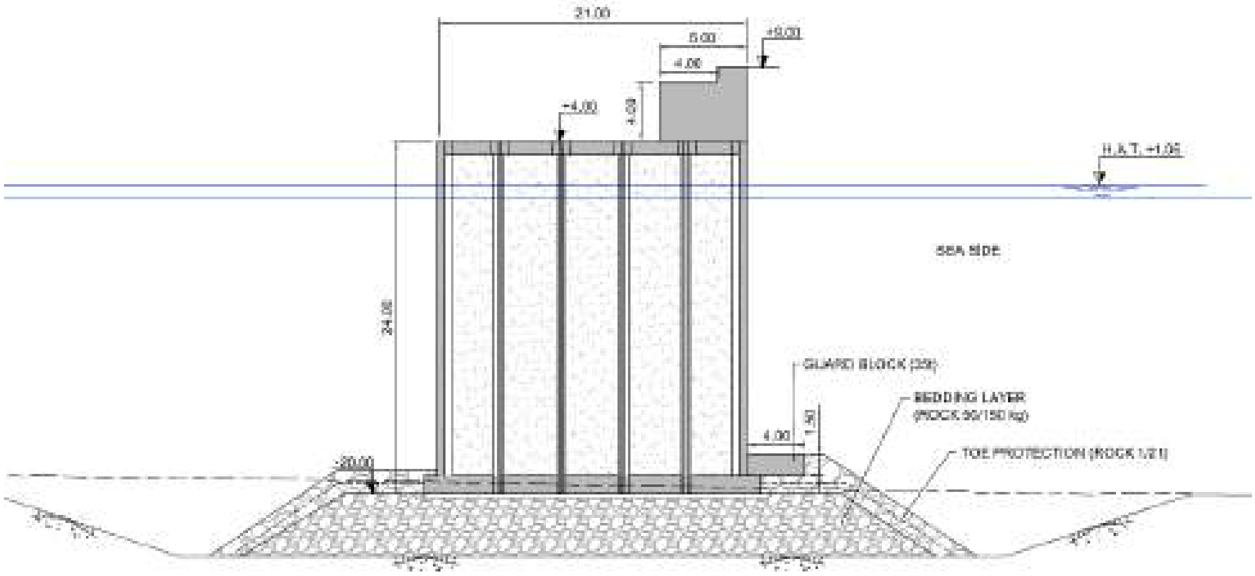


Figure 8. Vertical section with an admissible overtopped

ANNEXURE 5:
INITIAL ENVIRONMENTAL EXAMINATION

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GLOSSARY

AAR	Average Annual Rainfall
ASI	Archaeological Survey of India
BG	Broad Guage
BMT	British Maritime Technology
BoQ	Bill of Quantities
BOT	Build Operate Transfer
BW	Breakwater
CAGR	ompound Annual Growth Rate
CESS	Centre for Earth Science Studies
CD	Cross Drainage
CEO	Chief Executive Officer
CFE	Consent For Establishment
CFO	Consent For Operation
CGWB	Central Groundwater Board
CMFRI	Central Marine Fisheries Research Institute
CO	Carbon monoxide
COO	Chief Operating Officer
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
CSR	Corporate Social Responsibility
CTE	Consent to Establish
CZMA	Coastal Zone Management Authority
Db	Decibels
DLPC	District Land Purchase Committee
DMP	Disaster Management Plan
DO	Dissolved Oxygen
DPR	Detailed Project Report
DWT	Dead Weight Tonnage
EA	Environmental Assessment
EAC	Environmental Appraisal Committee
EC	Environmental Clearance
ECHS	Empty Container Handlers
EIA	Environmental Impact Assessment
EMC	Environmental Management Cell
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
ESMF	Environmental and Social Mitigation Framework
ESMP	Environmental and Social Management Plan
ESRO	European Seaports Organisation
FL	Flood Level
Fy	Financial Year
G.O.	Government Order
GIS	Geographical Information System
GSI	Geological Survey of India
GL	Ground Level
GoI	Government of India
GoTN	Government of Tamil Nadu
Ha	Hectares
HC	Hydrocarbons
HED	Harbour Engineering Department
HTL	High Tide line
HMV	Heavy Motor Vehicles
ID	Identification

IEC International Electro technical System
IFC International Finance Corporation
IMD Indian Meteorological Department
INCOIS Indian National Centre for Oceanographic Information Services
IR Indian Railways
IS Indian Standards
ISO International Organisation for Standardisation
ISSC International Ship Security Certification
ITV Internal Transfer Vehicle
IUCN International Union for Conservation of Nature
IVI Important Value Indices
KLD Kilo litres per Day
Km Kilometre
Kmph Kilometre per hour
KV Kilovolt
LA Land Acquisition
LBH Land Borehole
LC Level Crossing
LHS Left Hand Side
LHPP Local Hiring and Purchase Plan
LTL Low Tide Line
m Metre
MoEF Ministry of Environment & Forests
MSL Mean Sea Level
NAAQ National Ambient Air Quality
NABET National Accreditation Board for Education and Training
NANQ National Ambient Noise Quality
NCSCM National Centre for Sustainable Coastal Management
NE Northeast
NGO Non Government Organization
NW Northwest
O & M Operation and Maintenance
PA Particle Analysis
PAF Port Annex Facility
PAHs Project Affected Houses
PAPs Project Affected Persons
PDPs Project Displaced Persons
PFSO Port Facility Security Officer
PIA Project Influenced Area
RA Risk Assessment
R & R Resettlement and Rehabilitation
Rs Indian Rupee
SBI Cap State Bank of India Capital
SCR Shoreline Changes Rate
SE Southeast
SIA Social Impact Assessment
SMU Social Management Unit
SPCB State Pollution Control Board
STD"s Sexually Transmitted Diseases
STP Sewage Treatment Plant
T Tonne
TNCZMA Tamil Nadu State Coastal Zone Management Authority
TNPCB Tamil Nadu State Pollution Control Board
TNWA Tamil Nadu Water Authority
ToR Terms of Reference

UK	United Kingdom
WHO	World Health Organization
WBG	World Bank Group

1. INTRODUCTION

1.1. PROPOSED PORT DEVELOPMENT

The Colachel Port Project has been an important objective to Tamil Nadu and Indian Government for over 20 years. Two of the main reports written about this are the following:

- *Detailed Feasibility Study on Colachel Port, India* (November 2000) by Construction Industry Development Board of Malaysian Government for Tamil Nadu Government. The report analyses the traffic and market, and proposes a port near Manavalakurichi for container traffic only.

  The consultant presents a well protected port, but with some other problems like a difficult and expensive dredging on rocky soil, a river inside the basin which would generate the need for continued maintenance dredging, and very long and costly breakwaters.
- *Techno Economic Feasibility Study for Colachel Port* (July 2010) by i-maritime Consultancy Private Ltd. for Tamil Nadu Maritime Board (Ministry for Highways and Port). The report analyses the viability of establishing a muti-purpose commercial port, concluding that the port would only be viable if a captive thermal power plant is set up.

  I-maritime proposes a port on the Manavalakurichi shoreline which, from a technical point of view, has certain issues without easy solution (poorly protected from the southern swell, container terminals onshore and small berths, large and difficult dredging and big impact to the beach dynamics and shape).

Although the name of the project refers to Colachel as the site of the port, this study covers all the west coast of Tamil Nadu state, along the Arabian Sea, from Cape Comorin –Kanyakumari– to the border between the states of Tamil Nadu and Kerala.

This coast is composed of long beaches separated from each other by small headlands, where fishing villages such as Colachel, Muttom or Enayam are located.

To enable fishing activities, quite a number of rubble mound breakwater structures have been constructed taking advantage of the emerging rocks on the coast, creating a well protected beach and avoiding the littoral drift and scouring erosion of huge wave action during the southwest monsoon period (May-September).

Figure 1. Rubble mound breakwater near Colachel.

Besides, during the last years, two fishing ports have been developed. The first one in Colachel itself –which is being upgraded at the present time–and the other in Muttom – a private fishing harbour.

Figure 2. Colachel fishing harbour under construction (left) and wharf of the Muttom private fishing harbour (right).

The proposed project , objet of the present Initial Environmental Examination (IEE) is the Techno-Economic Feasibility Report for development of a Port near Colachel.

1.2. APLICABLE LEGAL AND POLICY FRAMEWORK

1.2.1. Laws and regulations

1.2.1.1. Policy initiatives for conserving marine environment

Haphazard anthropogenic activity along the coastal stretches during 1980's compelled the Government of India to issue instructions to all the coastal states about the eventual effects of inappropriate sea front development. The famous order stressed the environmental value of sandy beaches, by suggesting that coasts be kept clear from all human interference up to 500 m from the high water line.

This directive marked the beginning of an endeavor towards protecting the health of Indian coasts.

1.2.1.2. Coastal Regulation Zone Notification, 1991 (CRZ)

In 1991, the Coastal Regulation Zone Notification (CRZ) under Environmental Protection Act 1986 was issued by the Ministry of Environment and Forests to protect the 500 meter zone from the high tide line and along rivers and creeks upto the area of tidal action. The Coastal Regulation Zone in Tamil Nadu is categorized under three categories as below:

- Category I (CRZ I): Areas that are ecologically sensitive and important such as National Parks, Sanctuaries, Reserved Forests, Mangroves, Estuaries, Corals, areas close to breeding grounds of fish and other marine life, areas of outstanding natural beauty.
- Category II (CRZ II): The areas that have already been developed up to or close to the shoreline. For this purpose, developed area is referred to as the area within the municipal limits which is already substantially built up and which has been provided with drainage and approach road and other infrastructure facilities, such as water supply and sewerage mains.
- Category III (CRZ III): Areas that are relatively undisturbed and those which do not belong to Categories I and II. This will include coastal zone in the rural areas (developed and undeveloped) and areas within municipal limits where substantial development has not taken place.

1.2.1.3. Other Laws and Regulations related to coastal activities

Apart from the Coastal Regulation Zone notification, 1991 there are many legislations / acts and rules related to coastal activities. The following are the important ones:

Indian Fisheries Act, 1897; Indian Ports Act, 1902; Merchant Shipping Act, 1974, Wildlife (Protection) Act 1972; Water (Prevention and Control of Pollution) Act, 1974, Air (Prevention and Control of Pollution) Act, 1981; Indian Coast Guards Act, 1974; and Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981; Environment (Protection) Act 1986; The Petroleum Act, 1934; National Environment Tribunal Act, 1995; Hazardous Wastes (Management and Handling) Rules, 1989.

In addition to this, India has signed and ratified several international conventions relating to oceans and related activities. Some of these are related to marine environment and applicable to coastal area also. The important ones are: MARPOL 1973/1978; London Dumping Convention, 1972; Convention on Civil Liability for Oil Pollution Damages (CLC 1969) and its Protocol, 1976; Fund, 1971 and its Protocol, 1979; CITES, Convention on Biodiversity, 1992.

1.2.1.4. Coastal Zone Management Authority

The Government of India, MoEF has constituted an authority namely, the Tamil Nadu Coastal Zone Management Authority, to enforce the Coastal Regulation Zone notification. The Chairman of the Authority is the Secretary to Government, MoEF and the Director, Department of Environment is the Member Secretary.

1.3. INITIAL ENVIRONMENTAL EXAMINATION

The present study deals with the Environmental issues related to the Project in order to assess the likely impact.

IEE has been conducted within the short time available. The study mainly depends on secondary data on physiological condition of the area. Some field verifications have been undertaken by the study team for updating the secondary data when it was necessary.

IEE was carried out as part of this TEFR. Thus it can assure that the Project will be environmentally feasible. The general objectives of IEE study had cover the following:

- *To provide information about the general environmental settings of the project area as baseline data.*
- *To provide information on potential impacts of the project and the characteristic of the impacts, magnitude, distribution and their duration.*
- *To provide information on potential mitigation measures to minimize the impact including mitigation costs.*
- *To provide basic information for formulating management and monitoring plan.*

The indicative outline of the present IEE report is as follows:

- A. Introduction.
- B. Description of the Project.
- C. Description of the Environment.
- D. Screening of Potential Environmental Impacts and Mitigation Measures.
- E. Institutional Requirements and Environmental Management Plan.
- F Conclusions.

2. DESCRIPTION OF THE PROJECT

The advantageous geographical position, in terms of natural deep draft and close proximity to the international East-West shipping routeof Colachel(located in Kannyakumari District, Tamilnadu), leads tothe Union Government of India, through the V.O. Chidambaranar Port Trust (VOCPT), to study the Techno-Economic Feasibility Study to develop a Major Port at Colachel, to promote the regional development of this region.

The port location will be able to tap the potential mainly for development of a deep water international container transhipment port that will be able to handle the largest container vessels navigating the East-West shipping route. Besides, it will allow the possibility of exploitation of other potentials like shipyards, coal handling, cruises…

2.1. IDENTIFICATION OF ALTERNATIVE PORT LOCATIONS

Four possible locations were selected along the coast, Erayam, Colachel, Muttom and Kanyakumari .

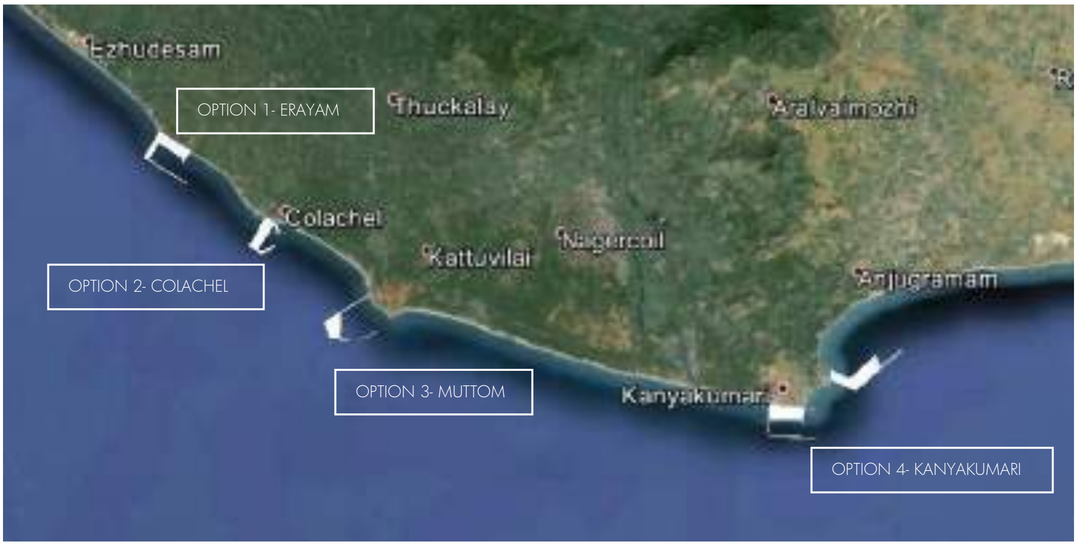


Figure 3. Initial proposed Port locations

A depth of 18-20 m basin has been pursued, enough for the largest container ships, and is dimensioned for a quay length of approximately 2000 m. This value is for reference only and will be adjusted once the traffic study has been made.

For the selection of the Proposed sites there have been analyzed the characteristics of coast: the physiographic units that compose it, the proximity to the coast of deep waters, proximity of river mouths, natural protection against the predominant wave or degree of urbanization of the area, using coastal landforms (capes or rock reefs), and avoiding locations in beach areas.
It has been searched a depth of 18-20 m for breakwaters, enough for the largest container ships, and is has been preliminary established a berth length of approximately 2000 m.(reference value).

2.1.1. Option 1 – Enayam

Taking advantage of Enayam reefs near the cape, a breakwater perpendicular to the coast is designed to reach the -20.00 m isobaths, which is very close to the coastline in this area. Then the breakwater turns to the East and is completed in parallel to the coast forming a rectangular basin with enough space for ships manoeuvre. Berths and terminals are created in the coastal area (with little human occupation) and the perpendicular to the coast breakwater.

This configuration allows expansion of the port in successive phases by the simultaneous extension of the breakwater berths, and terminals attached to the coast. Besides, this allows easy access of industrial areas to exploit the existence of the port. On the other side, the closeness to the beach makes necessary to build another containment structure to prevent siltation of berths in a medium-long term.

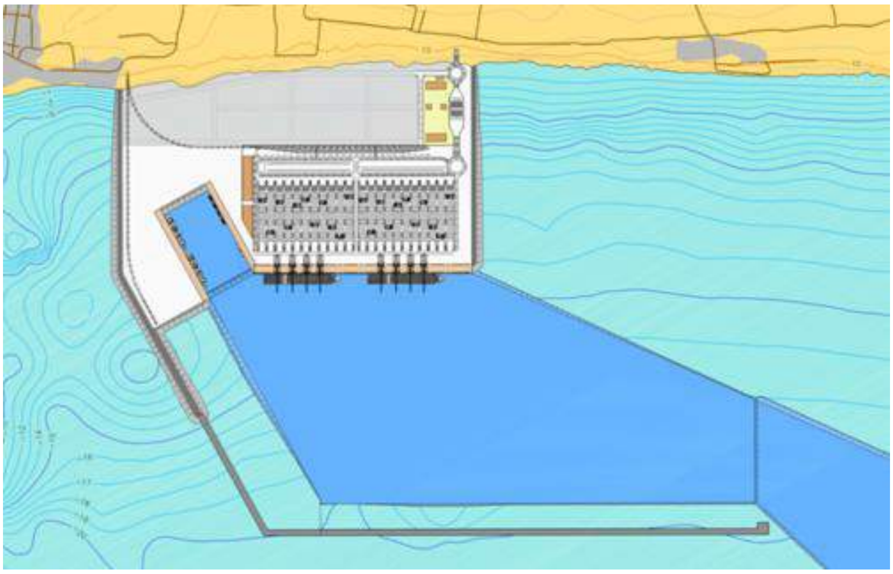


Figure 4.Option 1 Plan view.

2.1.2. Option 2 – Colachel

Off the cape in Colachel, a terminal perpendicular to the coast of approximately 2000 m is designed to reach the -20.00 m isobaths. A perpendicular to the coast berth, sheltered by a breakwater against the storms of the south and southwest, and a grounding barrier are designed. With the aim not to occupy the coastline, in this much more populated than the alternatives case. A small deviation of the river mouth would be needed to allow a width of 500 m to the operation area.

Figure 5.Option 2 Plan view

2.1.3. Option 3 – Muttom

Taking advantage of Muttom reefs, an offshore port reaching the -20.00 m isobaths. The port is connected to land though a bridge. This way, it is possible to minimize dredging, making phased developments and affect virtually no littoral drift, not causing barrier effects. Transport between port and land is penalized for import-export goods, but not for transhipment traffic.

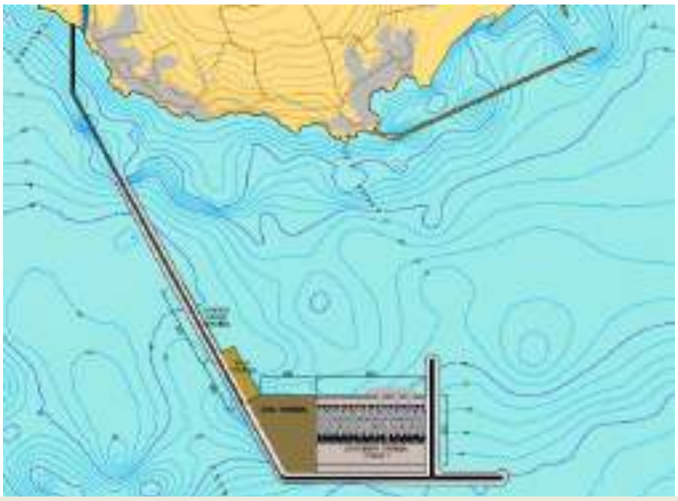


Figure 6.Option 3 Plan view

2.1.4. Option 4 – Kanyakumari

Two solutions could be possible in this area:
First one is placed between the two small capes of the south coast of Kanyakumari. It reaches the -20 m isobath though a breakwater perpendicular to the coast. This structure shelters the port against the waves coming from the west. Then, the main breakwater goes parallel to the coast. So do the berths, which are close to the land.

Between those structures, a basin of 1km wide will be created. Although the affected area has a high environmental a touristic value, the monument islands are respected.

Another possible solution is located in the East waters of Kanyakumary, which are a well naturally-sheltered area, and the shore area isn't occupied by beaches or population. On the other side, the existing drafts around 5-10 m and the flat profile of the seabed causes a first dredging as well as maintenance dredging to reach the drafts of major container ships.

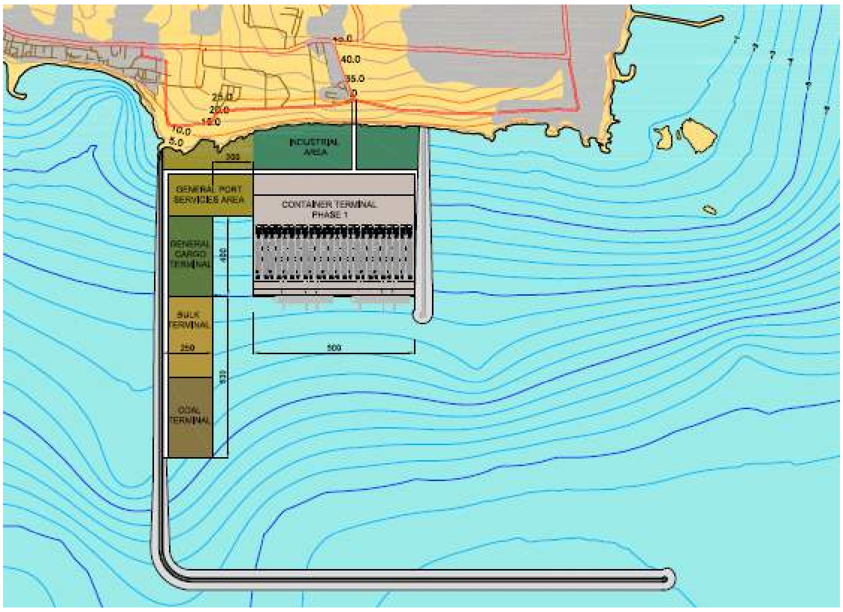


Figure 7.Option 4 Plan view

2.2. PROJECT GENERAL CRITERIA

2.2.1. Traffic and phasing

The Traffic and Market Study summarized on Section 4 provides an estimate of Colachel's trans-shipment and gateway traffic under multiple scenarios. It also explains in detail the factors that may substantially impact the traffic movements. Besides, the report provides traffic estimation for bulk (coal) traffic.

The conclusions drawn in the aforementioned study for the Base Case, which is the selected one to design the port facility, is shown in the table below:

Base Case	units	2018	2020	2025	2030	2035	2040	2045
Bulk Traffic	*in Mn MT*	-	-	3.3	6.6	9.9	9.9	9.9
Container - Gateway	*in Mn TEU*	0.6	1.0	2.1	2.9	3.9	5.0	6.2
Container - Trans-shipme	*in Mn TEU*	0.4	0.7	2.8	3.9	5.2	8.0	11.5
Total	*in MN MT*	15.4	26.2	79.4	111.1	151.2	210.6	284.1

Table 1. Traffic estimates for Base Case.

Three phases have been defined to size the berths and operational area of the port, which lead to:

- Phase 1: Traffic forecast for 2020.
- Phase 2: Traffic forecast for 2025.
- Phase 3: Traffic forecast for 2030.

Although a forecast for traffic has been made for years 2030 to 2045, planning a facility for such a long period is very risky. Many of the factors which have been used on the traffic study and nowadays are considered valid may change in the future. In any case, the port facility will be designed to be easily expandable beyond the 2030 traffic forecast.

According to this phasing, the expected traffic volume for each phase is presented below.

	Units	Phase 1 (2020)	Phase 2 (2025)	Phase 3 (2030)
Bulk traffic (coal)	M. Ton	0.00	3.30	6.60
Container traffic (total)	M. TEU	1.70	4.90	6.80

Table 2. Estimated traffic for each phase.

Although no estimations have been made for other traffic, some general cargo, liquid bulk or solid bulk is expected to be attracted by the new port.

2.3. MAIN FEATURES OF PROPOSED SOLUTIONS

The design of the port's facilities is the direct consequence of the traffic that it is expected to be able to attract in the future. In this sense, container cargo is obviously the primary activity, followed by, in a second phase and as a secondary activity, coal cargo. Furthermore, the fact that the port may attract small amounts of other types of general merchandise has been taken into account.

The proposed layout is the result of bringing together the environmental and physical conditions of the site with traffic expected by 2020.

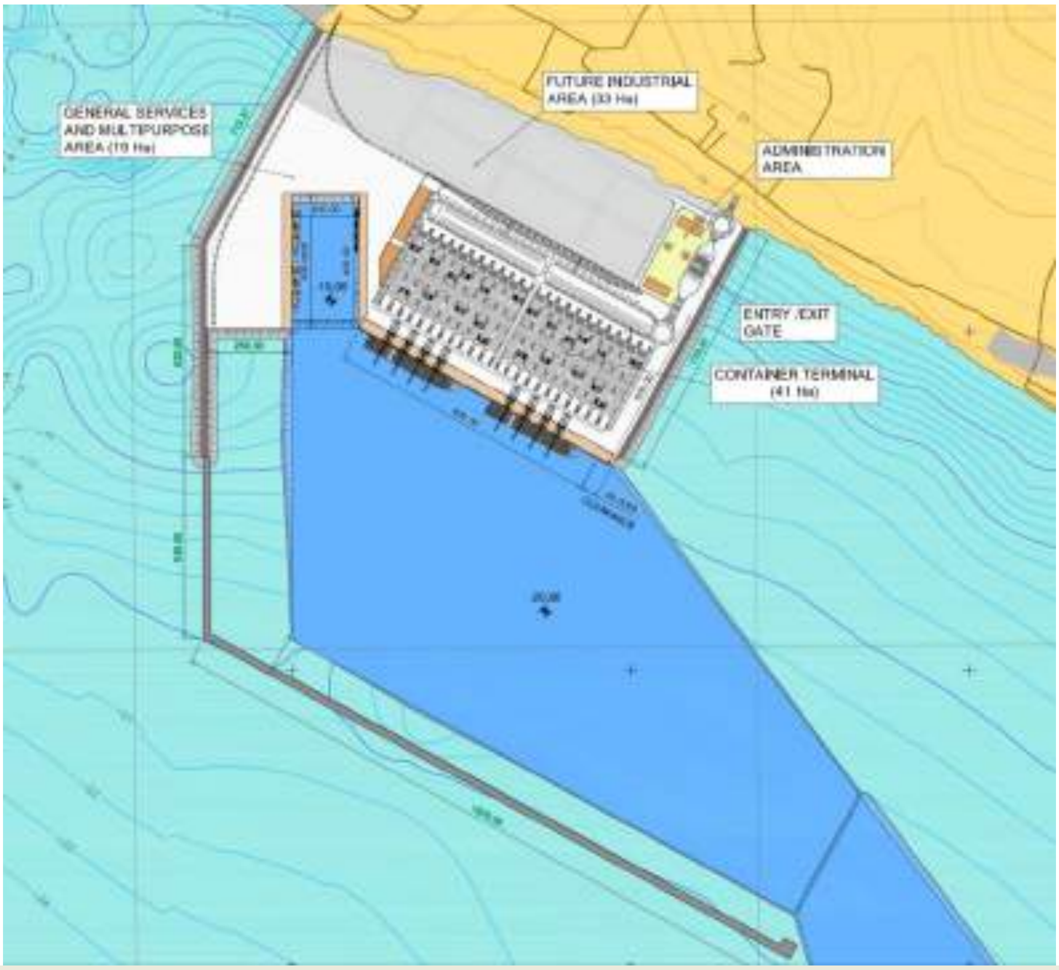


Figure 8. Port Layout

This layout is composed by the following main elements and figures:

Description	Units	Phase 1 (2020)
Berths (total)	m	1,400
Container (2 berths)	m	800
General Cargo (1 berth)	m	400
Ancillary vessels (1 berth)	m	200
Terminals/Yards	Ha	93
Container	Ha	41
General services and multipurpose area	Ha	19

Industrial area	Ha	33
Breakwaters	**m**	**4,630**
Rubble mound	m	2,140
Vertical	m	2,490
Dredging and reclamation	**Cu.m**	**10,123,273**

Table 3. Main elements and figures of the port

In the following chapters the criteria followed in the planning of Phase 1 of the port's installations and its principal characteristics is explained. There is also an advance of the principal characteristics of Phases 2 and 3, which covers up to 2030.

2.3.1. Breakwaters

a) General

- The main breakwater should be located around the -20.0 m depth line, so that the vessel channel does not require much initial or maintenance dredging.
- The main breakwater should be perpendicular to the main waves. This means a NW-SE orientation.
- To gain the expected depth, a breakwater approximately perpendicular to the coast should be constructed. This breakwater should have a N-S orientation, to allow wave incidence on the shore and, thus, allow the littoral drift and cleanness of the beaches.
- Between the 0 and -15.0 m depth line, a rubble mound-type breakwater, armoured with accropode or cubipod concrete units is the most economic type, while for deeper waters, a vertical breakwater made by concrete caissons is the cheapest solution.

b) Cross sections

For the breakwater design, a 200-year return period has been considered. This means 5.0 meters of wave height and a 11.5-second wave period.
As mentioned above, both rubble mound and vertical breakwaters have been preliminarily calculated. The results can be seen on the next figures.

- Rubble mound breakwater

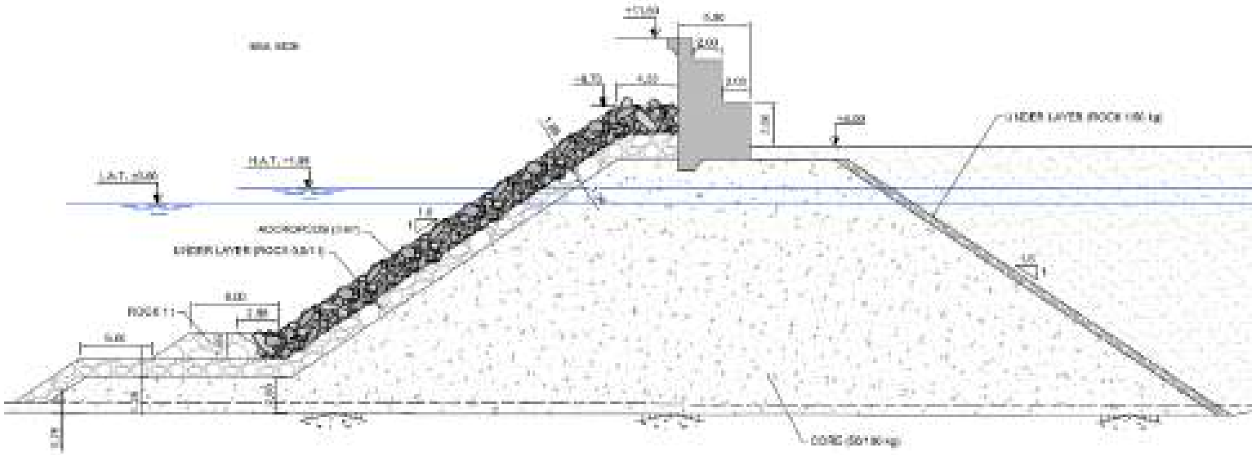


Figure 9 Rubble mound breakwater

The armour layer on the seaside consists of 12-ton accropods, a 1-2 ton rock underlayer and a core of 50-150 kg of quarry run. On the port side, the armour layer consists of rocks of 1-2 tons.

- Vertical breakwater

The vertical breakwater is made of floating concrete caissons filled with sand. For the toe protection, the same 1-2 ton rocks will be used, while the caissons will be 23 meters wide and 24 meters tall.

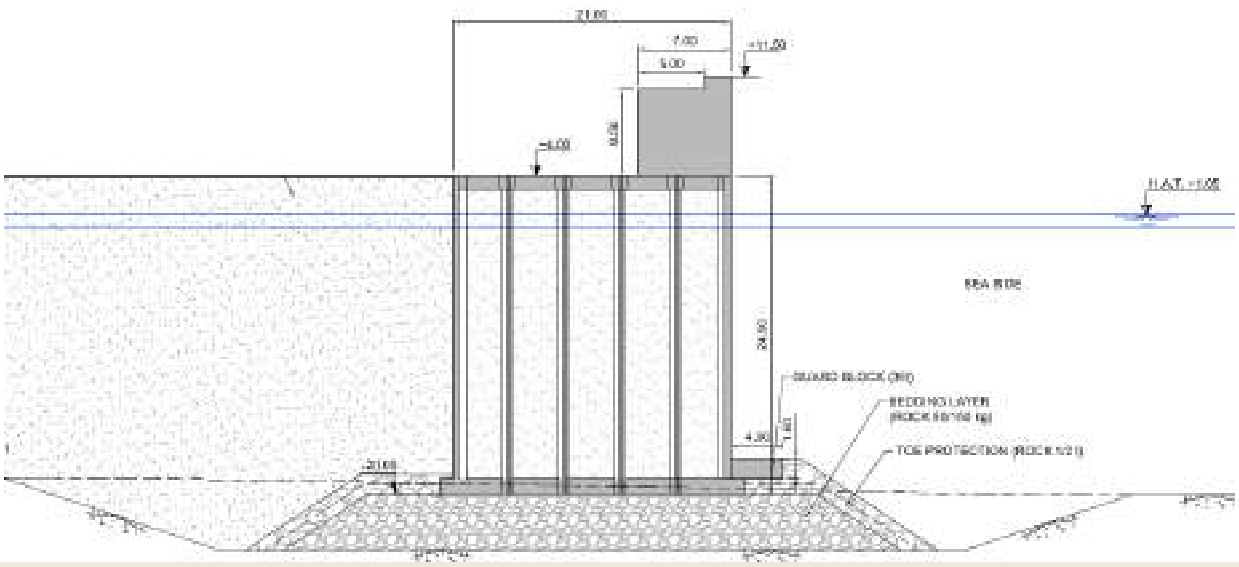


Figure 10: Vertical breakwater

2.4. FACILITIES

2.4.1. Container terminal

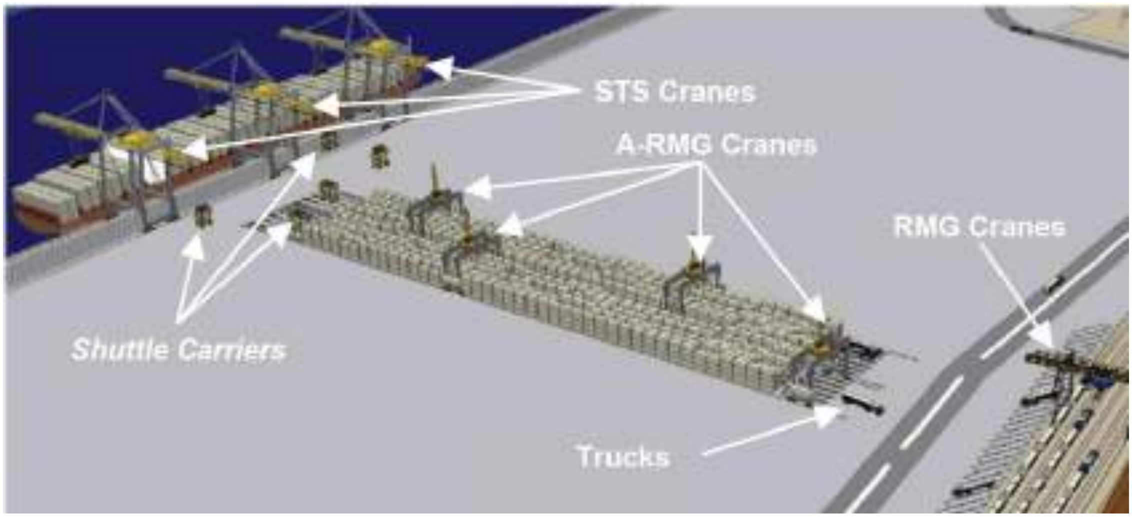


Figure 11. Scheme for container terminal operations

Its main features are:

- Berth-yard transfer: Handling of containers between the quay cranes and the yard cranes is made by shuttle carriers. The STS cranes leave the container on the pavement and a shuttle carrier takes it to the water-side transfer area of the yard, or vice versa.
- Container yard. An automated rail mounted gantry container crane (A-RMG) takes the container and stocks it in the yard. Whenever is needed, the crane takes it and leave it on the other side of the land-side transfer area, where a truck is waiting to be loaded. This can occur to the other direction- a truck leaves the container and the ARMG stocks it in the yard and whenever is needed the crane leaves the container o the sea side of the yard to be loaded into a ship.

  Usually every block is covered by two ARMG, one for the sea-side and the other for the land side.
- The connectivity from the yard to outside the port is as usual in every container terminal.

2.4.1.1. Berths

Berths must be sized to cater the estimated handlings over it. Other berths and terminals
Although there is no forecast for general cargo, a 400 m general cargo and multipurpose berth is included in the port layout. This berth will allow the container terminal to be very specialized and avoid interruptions in operations.
Besides, a 200 m berth for ancillary vessels such as tugs, pilots and mooring launches is included in the facilities.

2.4.2. Solid bulk terminal

Coal traffic is expected to begin in 2022. A solid bulk terminal is included in Phase 2 development to cater this cargo.

This terminal consists of a 400 m long and 20 m deep berth. To assess the berth capacity, the following table shows the parameters and values taken into consideration:

Description	Units	Value
Quay crane productivity	T/hr	2,000
Annual working days	Days/yr	365
Dayly working hours (3 shifts)	h/day	21
Berth capacity (ocupation)	%	75
Yard Capacity for loaded containers	**T/yr**	**11,497,500**

Table 4. Coal berth performance assumptions.

This calculation means the berth could cater all coal traffic with only one crane, although having only one might cause difficulties to serve ships in case of malfunction.
The stockyard is equipped with conveyors and stackers/reclaimers, standard equipment for this kind of terminals.
The following figure shows the layout of the terminal:

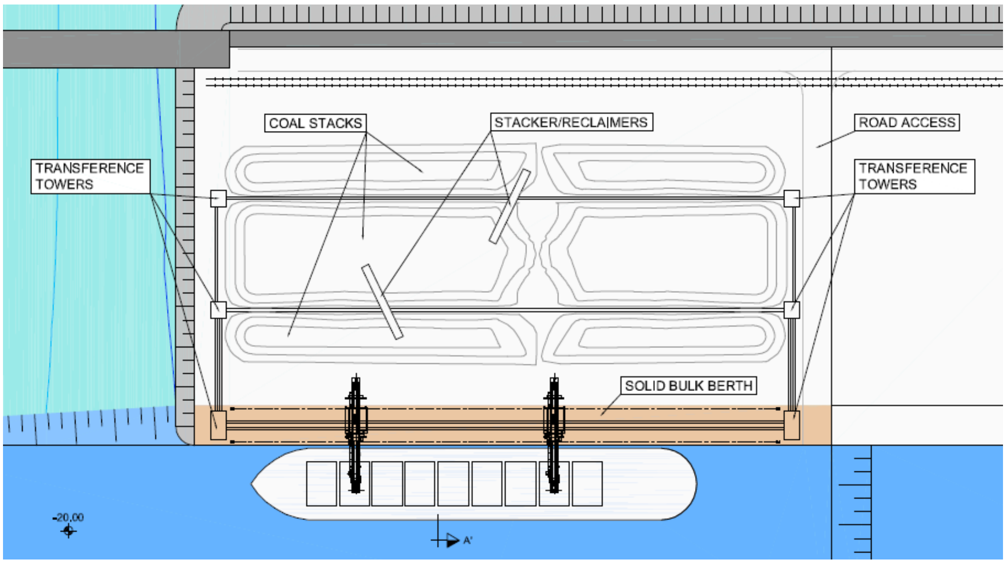


Figure 12. Coal terminal layout

2.4.3. Buildings

Some administration and control buildings will be required for the new port. The following list includes the most important ones –which have been foot printed on the drawings:

- Port administration building
- Police station
- Fire station
- Customs

The container terminal includes:

- Maintenance workshop
- Marine operations building
- Administration building
- Entry/Exit gates

Some other buildings might be added in future stages of the design process.

2.5. CONNECTIVITY PLANNING

2.5.1. Rail connectivity

A single lane broad gauge track runs parallel to the west coast of India. Several alternative layouts of a new railway which connects to the existing one have been analyzed to know which is better in terms of environmental impact, length, slopes, and earthworks.
All of them have been chosen according to the following criteria:

- Avoid densely populated areas.
- Limit the maximum slope to 0.12 %.
- Limit the minimum radius to 500 m, apart from connections on the existing railway and the port.

The most suitable two of them are shown in the figure.

Figure 13. Alternatives 1 (green) and 2 (black) for rail connectivity

The shortest and less costly option in terms of earthworks is alternative 1 (green). Specifically, a double broad gauge track has been considered.

2.5.2. Road connectivity

In the same way as the rail linkage, several alternative layouts of the four lane connecting road have been analyzed. The applied criteria for these layouts are as follows:

- Avoid densely populated areas.
- Use (as far as possible) the existing roads.
- Limit the maximum slope to 4 %.
- Limit the minimum radius to 300 m.

The most suitable two of them are shown in the figure.

Figure 14. Alternatives 1 (blue) and 2 (red) for road connectivity

3. DESCRIPTION OF THE ENVIRONMENT

3.1. INTRODUCTION TO THE STUDY AREA

Kanyakumari is the smallest district situated in the Southwest of Tamil Nadu, South India with a land spread of 1,684 sq. km. It has almost all ecosystems – forests, wetlands, freshwater resources, marine etc. The coastal ecosystem of this District comprises 68 km in length and is studded with 44 coastal fishing villages.

Since this district is situated at the extreme south of the Indian subcontinent, the coastline is formed nearly by the three seas, namely the Arabian Sea, the Indian Ocean and the Bay of Bengal. But the main part of the coast faces the Arabian Sea.

The coastal landscape of Kanyakumari District is mainly composed of beach ridges of rocky, sandy, clay in salt pan region and swampy nature in the estuarine regions. The 68 km long coast has a heavy concentration of fisher folk, almost one village per 1.5 km.

Coastline is exposed to relatively higher waves than the rest of the Indian coast due to its direct exposure to the Indian ocean. The oceanography of this region is controlled by three different seasons a) southwest monsoon (June to September), b) northeast monsoon (October to December), c) fair-weather period (February to May). The tidal range along the west coast of India increases from 6.5 m to 7.6 m towards south.

3.2. LAND ENVIRONMENT

3.2.1. Climate and Atmosphere

The climate of the state Tamil Nadu is tropical monsoon type. In the plains, the temperature during winter seldom goes below 18°C while in peak summer it rises to 43°C. Tamil Nadu receives rains from both the northeast and southwest monsoons. Maximum rainfall and occasional cyclones occur during the northeast monsoon. The Western districts receive the maximum rainfall while South districts receive low rainfall.

Unlike other districts, Tamil Nadu has a rainfall both during the South West and the North East monsoons. The South West monsoon period starts from the month of June and ends in September, While the North East monsoon period starts from October and ends in the middle of December. The average rainfall is as shown:

Year	South West Monsoon	North East Monsoon	Winter season	Hot weather season	Total	% Deviation (+ or – or =) from Normal
1993	5935,0	927,8	17,0	205,5	1743,5	+19,68
1994	492,8	1039,9	77,1	276,7	1886,4	+29,49
1995	595,7	630,3	41,2	509,6	1776,8	+21,97
1996	592,8	608,0	19,5	213,5	1343,8	-7,76
1997	593,0	646,5	10,6	269,2	1519,3	+4,29
1998	760,0	653,4	2,8	240,4	1656,9	+13,74
1999	667,8	1069,3	52,7	458,6	2248,4	+54,34
2000	590,4	602,0	204,1	138,8	1535,3	+5,39
2001	894,6	360,3	73,9	419,2	1748,5	+20,02
2002	650,9	484,8	28,2	341,6	1505,5	+3,34
2003	232,0	750,6	9,5	188,5	982,7	-32,54
2004	623,6	348,95	10,5	480,7	1463,8	+0,48
2005	729,0	667,7	32,8	461,5	1791,3	+22,96
2006	644,4	620,7	21,5	368,1	1654,7	+13,58
2007	732,8	550,56	14,42	260,7	1558,48	+6,97
2008	556,56	627,44	64,98	425,72	1674,70	+14,95
2009	438,29	528,15	0,69	333,82	1300,95	-10,69
2010	492,10	1105,22	57,23	451,04	2105,58	+44,53
2011	322,42	584,64	76,41	221,73	1186,63	-18,53

Normal data South West Monsoon 559,1, Normal data North East Monsoon 526,0, Normal data Winter season 50,2, Normal data Hot weather season 321,5 and Normal data Total 1.456,8.

Table 5. Time series data of rainfall by seasons from 1993 to 2011. Source: Asst. Director of Statistics.

The climate in Kanyakumari undergoes very slight variations .From April to June, Kanyakumari faces a very hot temperature that can reach up to maximum 35°C, whereas from November to February Kanyakumari remains coolest and the temperature overs around 21°C.

The average maximum temperature during May is 35,93 °C. The average minimum temperature recorded is 23,85 °C during January. The annual mean minimum and maximum temperatures are 23,78 and 33,95 °C respectively. On the other hand, sometimes due to the Northeast Monsoon gentle rainfall takes place between the month of October and December.

Kanyakumari Weather is assumed to be tropical. The summer season is soothing with sufficient warmth, whereas winter is never too cold. It is said that the humidity and temperature of this place remain comparatively high all through the year. Rainfall is quite common at any period of the year.

The Monsoon Season is relatively more precipitation than at any other seasons.

The general climate of Kanyakumari is pleasant. Both the south-west and north-east monsoon winds, the proximity of the sea and the dwindling heights of Western ghats greatly influence the climate. In Kanniyakumari rainfall is distributed over four seasons:

(a) south-west monsoon (June-Sept) 37 % and 33,7 rainy days

(b) northeast monsoon (Oct- Dec) 37,9% and 26,5 rainy days,

(c) winter (JanFeb) 2,7% and 2.7 rainy days and

(d) the hot weather summer seasons 21,7 % and 16,8 rainy days.

In the hill region the rainfall is uniformly distributed in both monsoons and maximum rainfall occurs during October and November. The annual rainfall varies between 600 mm and 1800 mm. On the whole this district gets an average annual rainfall of 1.369.5 mm with 79.7 rainy days.

Month	Max Temp	Min Temp
January	30,8	23,4
February	31,6	23,8
March	32,1	25,0
April	32,7	26,1
May	32,5	26,2
June	30,5	24,5
July	30,3	24,0
August	30,4	23,9
September	30,6	24,3
October	30,5	24,3
November	30,2	24,0
December	30,2	23,7

* Max Temp- Maximum average temperature
* Min Temp- Minimum average temperature

Table 6.: Temperatures in Kanyakumari district. Source: IMD, Pune.

The highest humidity is generally record in May with the value of 95 percent whereas the minimum of 5 percent is record during February. The maximum wind speed of 17,74 km/hr is recorded during August and the minimum wind speed of 5,53 km/hr is record during December. Wind velocity is low from October to December. The Sun Shine Hours is March-April forms the average bright sunshine hours. The maximum of 12,74 hrs/day has been recorded during April and the minimum of 5,74 hrs/day is recorded during November. The temperature data indicate higher and lower temperatures prevailed during monsoon period.

3.2.1.1. Wind and Cyclone

During summer, the wind was blowing predominantly from the NE direction. It reached a maximum speed of about 3 to 6 m/s. The average wind speed for this season was 0,6 m/s. In summer, almost 61,75% of the wind was calm less than 2 m/s.

The Monsoon season has two predominant wind directions, SW and NE, which depicts the two different seasons of monsoon (south-west monsoon and north-east monsoon). The average wind speed of this season was recorded at 0,5 m/s and 60,36% of the total wind in that region was calm.

Higher wind speeds were recorded in the range of 2 to 3,5 m/s. In the winter season, the wind was blowing from NE direction predominately. The wind speed was in the range of 3,5 to 6 m/s. The average wind speed was recorded at 0,6 m/s.

The coastal area of Tamil Nadu comes under the moderate damage risk zone as per the cyclone hazard map prepared by the Building Materials and Technology Promotion Council (BMTPC). The cyclone hazard map is given in next figure

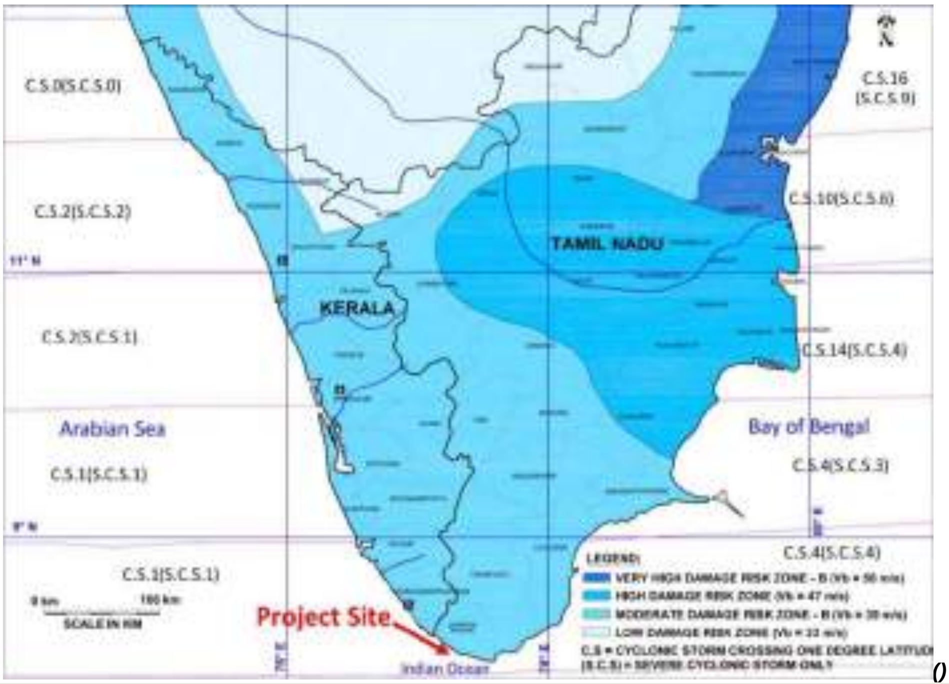


Figure 15. Wind and cyclone hazard map of Tamil Nadu and Kerala. Source: BMTPC, 2012.

Only three major cyclones have been reported since 1977 in and near the coast of study area, they are listed in next table.

Date	Details
November 8-12, 1977	Crossed Tamil Nadu (TN) coast within 10 km to south of Nagapattinam early morning of November 12, 1977. Weakened into a cyclonic storm by that evening over interior parts of TN & emerged into Laccadives off North Kerala coast on the morning of 13th as a deep depression. Maximum wind recorded was about 120 kmph (65 kt) on 12th morning at Thanjavur, Tiruchirapalli and Podukottai. 560 people died and one million people were homeless. 23,000 Cattles perished. Total damage to private and public property was estimated to be 1550 million
November 19-24, 1978	Crossed between Kilakkarai, Rochemary and Ramanatharam District of TN State on 24th evening as a severe storm emerged into the Arabian Sea off Kerala coast as a deep depression on 25th morning. Batticola of Sri Lanka reported maximum wind speed northerly 145 kmph. In India, 5,000 huts were damaged and total damage was estimated to be around ` 50 Million.
November 15-23, 1977	Crossed near Honavar, Karnataka and had high impact on Kerala coast. Tidal waves were reported to have damaged 620 fishing vessels.

Table 7.: Cyclonic History (Source: IMD, 2012: http://www.imd.gov.in/section/nhac/static/cyclone-history-as.htm)

3.2.1.2. Noise

To establish the ambient noise in the study area, monitoring of ambient noise level will be carried out at representative locations in the study area using a sound level meter over a period of twenty-four hours, with uniform interval of one hour, in each season.

The sampling locations varied in nature from silence zone to residential areas.

Ambient noise level or sound pressure levels (SPL) will be measured by a Portable sound level meter. A-weighted equivalent continuous sound pressure level (Leq) value will be computed from the values of A-weighted SPL. Noise Measurements will be carried out as standards as given by the Central Pollution Control Board (CPCB). At each location, noise monitoring will be conducted continuously over a period of 24 Hours to obtain Leq values at uniform time intervals of one hour.

3.2.2. Physiography

Three major units are recognised in Tamil Nadu from west to east. The western part comprises the Western Ghats roughly trending N-S and marked by a continuous range of Hills, extending from Nagercoil in the south upto Nilgiri -Bilgirirangan Hills in the north and further northwards through Karnataka. The elevation of these Hills ranges between 1.275 m and 2.637 m, where Doddabetta is the highest peak in the Nilgiri Hills. The east-west trending Palghat Gap is a prominent physiographic break in the Western Ghats. The beaches are plain and are devoid of sand dunes.

The shadow areas of the pocket beaches are intermingled with coconut trees and buildings. Inward from the shoreline, agricultural land and coconut plantations are present in between human settlements with a semi urbanised or rural set up. The region is densely populated predominantly by fishermen communities.

The south of Tamil Nadu is named Cape Comorin is the southernmost Indian the subcontinent point. It is a rocky promontory located at the end of the mountain range of the Western Ghats, which administratively belongs to the state of Tamil Nadu. Two seas edge of the Indian Ocean, Arabian sea and the Bay of Bengal, and the ocean itself, are there. Cape separates two important coastal regions of India: east, the Coromandel coast and the west coast of Malabar.

3.2.2.1. Topography

The eastern and south part of Tamil Nadu is marked by a coastal plain with associated landforms like vast tidal flats, continuous beach ridges, estuaries and lagoons and a narrow but fairly continuous beach.

The coastline of Tamil Nadu comprises a number of cusps, spits and wave cut platforms and several palaeo-shorelines. Some of the palaeo-shorelines extend inland suggesting periods of transgression and regression. The ongoing geodynamic process is generally progradation along the coast, which is modified at several places by erosion and deposition by aeolian and fluvial agents. The eastern areas of the central part of the state are marked by the depositional regime of many Rivers manifested by typical fluvial features like levees, channel bars and palaeochannels, back swamps and vast flood plains.

The Kanyakumari district encompasses the most southern forest tracts of the Western Ghats. The tract has its significance in possessing peculiar types of micro-habitats due to its geographical location, physical structure and varying altitudes. It has a peculiar constitution of the eastern, western as well as southern slopes of the Western Ghats into its territory.

The terrain is undulated with steep valleys and ridges rising above 1000 MSL at many places. It has an overall altitudinal range of about 50 MSL to 1650 MSL at Mahendragiri peak. The nature of vegetation formations together with climate and physical features of the landscape contributes to the habitat pattern of a region. It is particularly rich with its large number of microhabitats due to its exposure to wide range of climatic conditions and its southern most geographic position in the subcontinent.

3.2.2.2. Geoporphology and Geology

The Southern Granulite Terrain (SGT) of India, covering the states of Tamil Nadu and Kerala and the marginal zones of Southern Karnataka, was earlier considered to be the southern extension of the Granite-Greenstone terrain of Dharwar Craton exposed at a deeper tectonic level. This concept was based on the observation that the grade of metamorphism gradually increases from north to south. Geochronological and isotopic studies have brought to light that the southern part of the SGT lying south of Palghat – Cauvery Lineament (PCL) has a geological history distinctly different from the Dharwar Craton. These studies have shown that the terrain lying north of PCL shows crustal growth during the period from 3400 to 2500 Ma. In contrast, crustal growth in the terrain south of PCL is considered to have taken place predominantly during Post-Archaean times, as constrained by Nd model ages (Harris et al., 1994). T

his terrain might have witnessed several cycles of metamorphism, the most pervasive being the 550Ma Pan-African granulite facies event as constrained by isotopic systematics (Unnikrishnan Warrier et al., 1995b; Jayananda et al., 1995, Bartlett et al., 1995, Ghosh et al., 1998).

In view of the contrasting geological history recorded by the terrains north and south of PCL, the SGT has been divided into the northern Archaean Craton (Dharwar Craton) and the southern Proterozoic (Pandian) Mobile Belt (GSI, 1994) with the PCL marking theboundary between them.

Crystalline rocks of Archaean to late Proterozoic age occupy over 80% of the area of the state, while the rest is covered by Phanerozoic sedimentary rocks mainly along the coastal belt and in a few inland River valleys. The hard rock terrain comprises predominantly of Charnockite and Khondalite groups and their migmatitic derivatives, supracrustal sequences of Sathyamangalam and Kolar groups and Peninsular Gneissic Complex (Bhavani Group), intruded by ultramafic-mafic complexes, basic dykes, granites and syenites.

The sedimentary rocks of the coastal belt include fluviatile, fluvio-marine and marine sequences, such as Gondwana Supergroup (Carboniferous to Permian and Upper Jurassic to Lower Cretaceous), marine sediments of Cauvery basin (Lower Cretaceous to Paleogene), Cuddalore / Panambarai Formation (Mio-Pliocene) and sediments of Quaternary and Recent age.

In Kanyakumari District, heavy mineral concentrations in beach sand occur as detached patches along the east coast between Colachel and Kanyakumari over a distance of about 75km. A total of 45,75,605 tonnes of heavy mineral concentrates have been estimates by the Atomic Minerals Division on the beach between Thingattanam and Illinjam, Midalam and Colachel, Colachel – Manavalakurichi, Vajakkalurollankodu, Chinnavillai-Manavalakurichchi, Periakattuthurai-Manakkudi and from Manakkudi to Kovakulam in Kanyakumari District. The sands between

A total of 1.68 million tonnes of shell limestone occurs near Kovalam, Kanyakumari, Lipuram, Vattakottai and Kanagappapuram in Agastheeswaram Taluk of Kanyakumari District. About 81,300 tonnes of shell limestone occur north of Rameswaram.

Moreover, in Kanyakumari District, irregular pockets of phlogopite were traced near the contact of charnockite and leptynite close to Tiruvidamkode and Eraniel. They are not of economic importance.

Geomorphology Kanyakumari district is bordered by Western Ghats (Ridge and valley complex) in the West. Western Ghats form an elevation of 200 m amsl from these foothills in the west. The areas gently slope to southeast towards the Gulf of Mannar attaining an elevation of 25 to 30 m amsl. The eastern and central tracts are quite barren, but there are a few isolated knife edged hillocks. The coastal tracts are occupied by the marshy swamps and number of sand dunes (Teri sands). The prominent geomorphic units identified in the district through interpretation of Satellite imagery are 1) Structural Hills 2) Bazada 3) Valley Fill, 4) Flood Plain 5) Pediment, 6) Shallow Buried Pediments, 7) Deep Buried Pediments, and 8) Coastal Plain.

The geology of this district is comprises of the following rocks/sediments:

- Precambrian Crystalline: Precambrian crystalline rocks, which consist of khondalites, gneisses and incipient charnockites, have significant composition in this region.
- Basic Intrusives: Basic intrusives like gabbro and dolerite are present in the Precambrian crystalline rocks.
- Neogene Sedimentary Rocks: Neogene sedimentary rocks are present in the coastal region. It comprises of carbonaceous clays with lignified tissues/coal seams, china clay and friable sandstone.
- Laterites: Laterites are of the recently formed litho units, which are formed above the Precambrian crystallines and Tertiary sedimentaries.
- Quaternary Sediments: Quaternary sediments like sand bars, sandy hats, alluvial sands and lacustrine deposits. These sediments are found in patches and are separated by laterites.

3.2.2.3. Seismicity and Earthquake

The seismo-tectonic faults and earthquake zonation is shown in next figure. From the map it is evident that no major/regional seismically active faults, thrusts or trenches are present in the project area. The proposed project area is located in Zone III - the moderate damage risk zone.

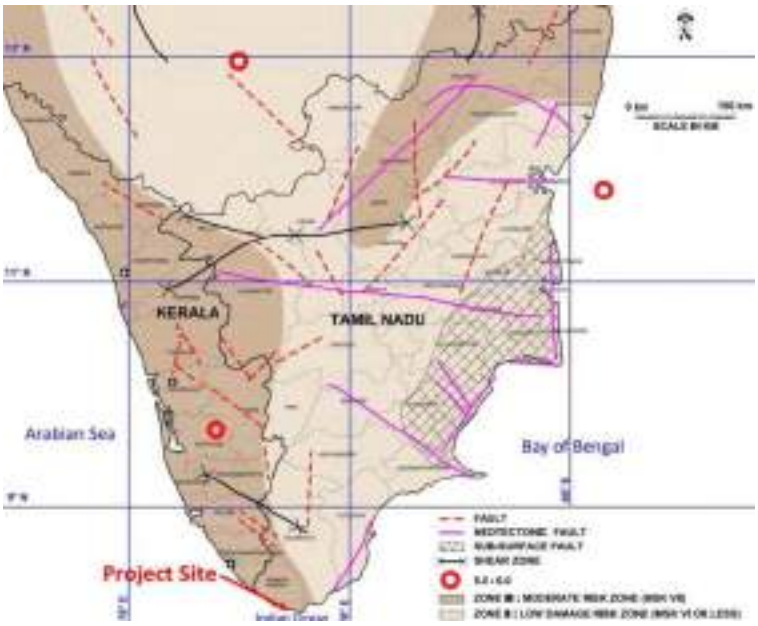


Figure 16. Seismic and Earthquake Zones and Regional Faults in Tamil Nadu and Kerala.

3.2.2.4. Soils

To assess the soil quality of the project area, the physico-chemical and fertility characteristics of the soils within the study area were examined by specific studies in the Kanyakumari area. Soil texture of the area varied from sandy clay loamy to loamy. Soil pH was observed to be neutral to slightly alkaline. Electrical conductivity varied from 100 to 250 µS/cm. Organic matter content in the soil samples, which indicates the soil fertility, was observed to be very variable, high in some places and in other sites it was observed to be comparatively low, indicate the poor fertility of the soil in these areas.

The concentration range of Nitrogen was similar in all the sampling locations, from 30 to 70 mg/kg and concentration of Phosphorous was in the range of 1 to 20 mg/kg. The soil pH is between 4.5 to 8.0. The minerals in soil - nitrogen: low to medium, phosphorus: medium, potassium: high

The soils of Kanyakumari district can be classified into i) Red Soil, ii) Red lateritic soil, (iii) Brown soil and iv) Coastal sand. The soils are mostly in-situ in nature, lateritic, earthy and pale reddish in colour. They are derived from laterisation of gneisses. The soils derived from gneisses are mostly brownish. The thickness of soils in the mounts is almost negligible whereas in the valleys it is around 2 m. The lateritic type of soil occurs in Thiruvattar, Munchirai, Kurunthancode, Rajakkamangalam, Killiyur, Thuckalay and Melpuram blocks. The mixed type of Red and alluvial soils, occur in Agastheeswaram and Thovala blocks. The coastal sand occurs in the western side of the district. The coastal alluvium sand is of high fertility.

3.2.2.5. Coastal Geomorphology

The project site typically has cliffs fronted by narrow sandy beaches. The stretch in the vicinity of Enayam and fishing harbour has headlands with pocket beaches. The beachs develop during the non monsoon period and erodes with the onset of monsoon.

Seawalls are constructed at most of the stretches as the erosion is severely affecting the fishermen who are living very close to the coast. Breakwaters are constructed at the coastal inlet to provide adequate training works to the entrance channel. The studies have indicated that this part of the coast is experiencing high wave energy with southerly long-shore drift during the monsoon and northerly for the remaining periods. Net erosion is noticed towards north along the coast. This indicates the net littoral drift direction is towards north.

3.2.3. Water

3.2.3.1. Surface Water

The state, because of its location along the Bay of Bengal as well as the Indian Ocean on the coastal region of the Eastern Ghats, has got many rivers flowing within its geographical boundary so as to get drained in those huge water bodies. The network of rivers in this state of south India is formed of many famous rivers and their tributaries and distributaries. Flowing eastwards, all or most of these rivers are completely rain fed and originates from the Western Ghats in India.

Figure 17. Tamil Nadu rivers. Source: Mapsofindia.com

The major river in Kanyakumari district is Thamirabarani River locally known asKuzhithuraiar. The origin of Thamirabarani River is in the Western Ghats and the river confluences with Arabian sea near Thengapattanam, about 56 km west of Kanyakumari town. This river has two major tributaries with the Pechiparai Dam and Perunchani Dam respectively built across them, Kodayar and Paralayar.

Kodayar River rises in a southerly direction flowing for a length of 10 km from its origin, leading to natural drainage. There are many tributaries for the Kodayar River of which Chittar River I and Chittar II, with their dams, are the major ones. Later, it flows in a southwesterly direction and south of Kuzhithurai and joins the Arabian Sea near Thengapatnam, which is at a distance of 56 km west of Cape Comorin. The river flows through rugged terrain through a succession of falls and cascades. One such fall lies south of Tiruparappu.

The Pazhayar River originated at an altitude of 1.300 m amsl in the Mahendragiri hills and the river water taken away through channels for irrigation. The river is benefited by both SW-NE monsoons. It completes its 20 km journey after joining the Arabian Sea. Its creek can be seen near Manakudy, 12 km south of Nagarcoil. The river Valliyar originated at an altitude of 950 m MSL at the Vallimalai Hills and has a very limited irrigation system. The length of the river is nearly 29 km, and period of flow of water in this river is for 6 months. Near Manavalakurichi the river joins in the Arabian Sea.

Figure 18. Kanyacumari rivers. Source: Mapsofindia.com

3.2.3.2. Estuaries

There are three important riverine ecosystems, which confluence with Arabian Sea, in Tamil Nadu: Thengapattinam estuary, formed by river Tampirabarani in between Thengapattinam and Eraiummanthurai (in North-East), Valliyar estuary formed by the river Valloiyar near Kadiapattinam (in Sout-West) and Manakudy estuary formed by the confluence of river Pazhayar in Manakudy, in Kanyakumari in the study area.

Apart from these are three minor estuaries in Kanyakumari. They are Enanyumanthurai estuary near Thengapattanam, Pambar estuary near Colachel and Pantri estuary near Rajakkamangalam.

These are formed by the drainage canal excess waste during monsoon and the water drained from the irrigational fields mixing with sea.

3.2.3.3. Flood

The flood hazard map of India is given in next figure. As per the map, the Tamu Ladi is flood prone and has a probable maximum surge height of 3.0 m. Flood in Kanyakumari are highly localised due to undulating terrain features except sandy plan coastal areas. Land ward side of the project area is highly undulating with hills and valleys. Generally, the low lying areas get flooded during the south west monsoon season. The worst flooding ever reported from 1905 to 2005 due to rainstorms was in July 1994, in which 209 human lives were lost and crop worth 1445 million was damaged (De et al 2005).

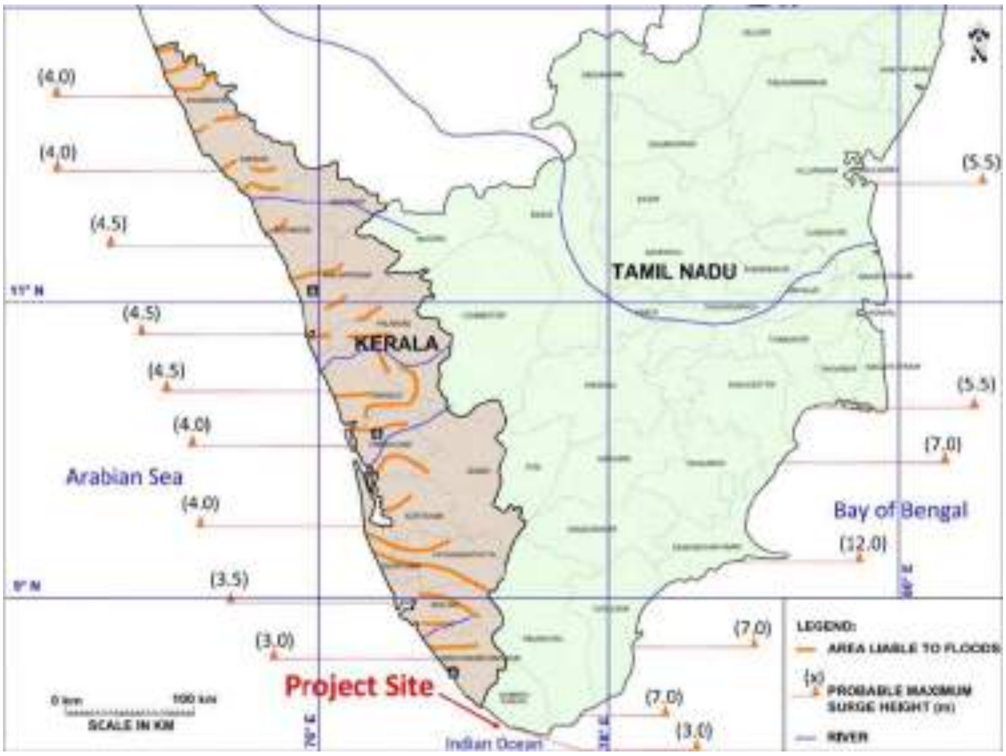


Figure 19. Flood Hazard Map of Tamil Nadu and Kerala. Source: BMTPC, 2012.

3.2.3.4. Coastal Erosion in Kanyakumari District

Coastal length of Kanyakumari district along Arabian Sea is 59 km and along Bay of Bengal is 11 km. Breakwaters like walls & groynes are sea erosion control measures for maintaining seashores.

RMS walls are almost constructed in entire length of sea shore of Kanyakumari district which is comparatively & densely populated district in Tamilnadu and has valuable lands with roads along shoreline. Walls are rubble mound flexible breakwater structures tends to settle down continuously due to scouring erosion. Moreover the stability of interlocking of heavy armour stones have been broken by knocking/impact of huge wave action during southwest monsoon period (May-September). Non-proper and timely Non–maintenance of RMS Walls during the past years leads to heavy damages/failures.

Groynes are to prevent heavy erosion indirectly by depositing the beach sand carried by littoral drift parallel to the seashores (long shore sediment transport.

Figure 20. Breakwaters in projectc area. Source: compiled by author.

3.2.3.5. Ground Water

The Tamil Nadu district is underlain by both porous and fissured formations (Plate-II). The important aquifer systems are constituted by i) unconsolidated & semiconsolidated formations and (ii) weathered, fissured and fractured crystalline rocks.

PLATE - II

Figure 21.: Hidrogeology Kanyakumari district. Source: Central Ground Water Board.

In the areas underlain by crystalline rocks, occurrence of ground water is essentially limited to zone of weathering and fracturing. Generally the hard rock aquifers are heterogeneous in nature, which is indicated by the variations in lithology, structure and texture. Ground water occurs under phreatic condition in the weathered mantle and semi-confined to confined conditions in the fracture and fissured zones of these rocks. Thickness of weathered material varied widely from less than a meter to more than 20 m. The depths to water levels in these formations vary from 8 to 18 m bgl. The depth of dug wells tapping crystallines ranging from 10 to 20 m bgl.

The unconsolidated formations in the East coast are exposed as patches over a stretch of about 10 km. The thickness of the formation is about 10 to 30 meters and the depth of the formation increases towards the sea. The depth to water level ranges from 8 to 18 m bgl. The Alluvium with intervening crystalline outcrops are noticed as patches west of Kanyakumari. The ground water occurs under water table to semi-confined conditions. The depth to water level ranges from 6 to 10 m bgl and the discharge ranges from 10 to 20 m^3/day. The sand dunes occurring between Vayakkallur, bordering Tamirabarani River, and Marthandamthuri for about 10 km stretch, is well protected by the Parvathi-Puttanar canal from Sea Water intrusion. In the sand dunes ground water occurs under phreatic condition. The depth to water level ranges from 4 to 8 m bgl and the discharge ranges from 30 to 80 m^3/day.

The yield of large diameter wells, tapping the weathered mantle of crystalline rocks ranges from 150-200 m^3/day and are able to sustain pumping for 2 to 4 hours per day. The yield of large diameter wells tested in crystalline rocks ranges from 150 to 200 m^3/day for drawdown of 1 to 3 m. The yield characteristics of wells vary considerably depending on the topographic set-up, litho logy and nature of weathering.

The transmissivity of weathered formations computed from pumping test data using empirical methods ranges from 12 to 22 m^2/day. The specific capacity in the fissured formation ranges from 2.89 to 153.74 lpm/m/dd. In the porous formation the specific capacity values vary from 6.31 to 28.7 lpm/m/dd. The yield of bore wells drilled down to a depth of 36 to 200 m bgl, by various state agencies mainly for domestic purposes. The discharge ranged from 2.05 to 33.13 lps.

The aquifer and well parameters of the wells show wide variation, both in crystalline and sedimentary formations. The depth to water level in the district varied between 5.27 and 16.70 m bgl during pre-monsoon (Plate-III) and varied between 2.47 and 11.32 m bgl during post monsoon (Plate-IV). The seasonal fluctuation shows a rise in water level, which ranges from 3.71 to 7.06 m bgl. The piezometric head varied between 2.66 to 20.06 m bgl during pre monsoon (May 2006) and 1.19 to 14.57 m bgl during post monsoon (January 2007). It is evident that the groundwater table is recharged during monsoon

The groundwater level of the project areas is recorded 5.0 m bgl in premonsoon and 2 – 5 m bgl in post-monsoon period. However, the groundwater in project area would being over exploited. This is due to high population density and indiscriminate extraction of groundwater for domestic and agricultural purpose through bore wells and dug wells.

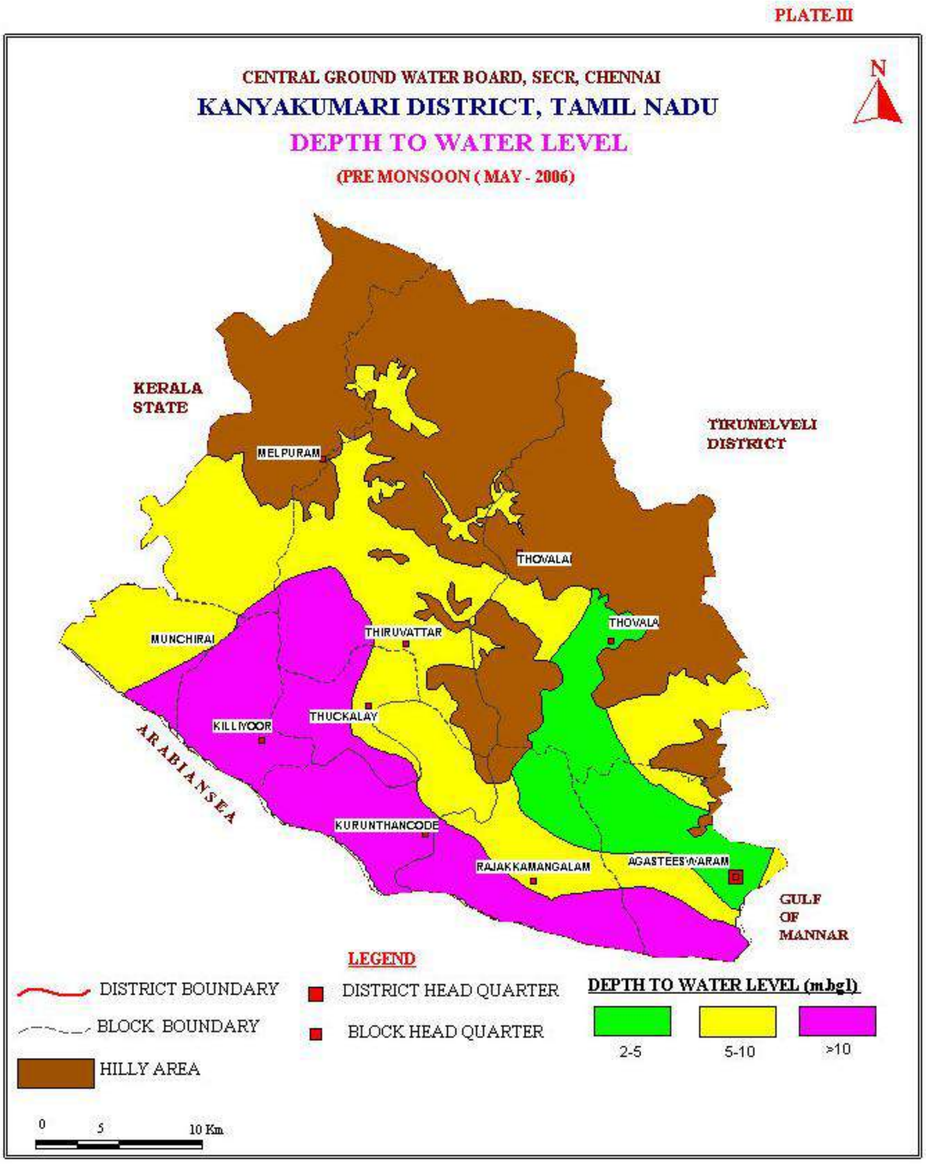


Figure 22. Depth to Water Level pre monsoon Kanyakumari district. Source: Central Ground Water Board.

3.2.3.6. Seawater intrusion

In the urban and agricultural areas bordering the seas, the coastal aquifers prove to be an important source of groundwater resource. It is seen that seawater is the most common pollutant of freshwater in coastal aquifers.

Coastal aquifers that have their end boundaries in contact with sea or other saltwater bodies often get intruded by saltwater, as a result of overexploitation, and due to the various other activities of human beings. The major problems in the groundwater sector of coastal areas are over development leading to the ever-increasing fresh water demands, declining water table leading to reduction in sustainability of tubewells and salinity ingress in coastal aquifers. Large scale extraction of groundwater is done for irrigation purposes as well as for drinking.

The groundwater in the coastal basin extracted for the requirement of industrial complex including the port trust and city requirements. This has lead to lowering of the water table in many areas. In some big cities, over tapping of ground water for drinking water has lead to seawater intrusion and further extraction has been banned.

3.3. BIOLOGICAL ENVIRONMENT

3.3.1. Flora and Vegetation

The coastal strip and the inland related ecosystems represent both a dynamic natural environment and an important context in which a diverse range of human activities, as well as geomorphologic and biological processes, interact. Thus, overexploitations, over inhabitation, overgrazing and socioeconomic issues have disturbed the natural vegetation, faunal community and ecological process. The disturbance caused to the natural vegetation has threatened the existence of various rare species of flora and fauna due to habitat destruction. Particularly for the study area, currently much of the natural vegetation is being converted into agricultural land. Sand dune vegetation comprises vital components of coastal sand dune habitats owing to their bioengineering role in sediment accumulation, sand binding and land building processes. Therefore, the original vegetation can only be found in a small part of the coastal strip. The inland area has been transformed into cropland throughout the centuries. The most abundant plant species along this narrow coastal strip within the study area are:

- *Borassus flabellifer, Palmyra Palm*
- *Prosopies juliflora,* invasive plant, small tree or bush (South America).
- *halopyrum mucronatum*
- *Casuarina equisetifolia*
- *Ipomea sp.*
- *Pandanus sp.*
- *Brachiaria ramosa*

	
Casuarina plntation on the shoreline	Halopyrum mucronatum, a common sand dune plant

	
Enayam coast general view	Enayam shoreline
	
Palmyra palm (*Borassus flabellifer).* Enayam coast	*Pandanus sp.* Shoreline of Enayam coast

Figure 23. Most representative vegetation species in the coastal fringe

The coastal inland area is very flat and slightly tilted away from the coast. This, together with the sandy soil present, has helped drastically transform the area into cropland. Coconut plantations are most widespread, followed by coconut crops mixed with other fruit trees, such as cashew nut, jackfruit, mango, banana and aonla, and vegetables like tomato, brinjal, bhendi and tapioca.

Any soil that can be flooded and drained has been used as rice field. There are also a few small vegetable crop fields, housing and land devoted to other uses amongst the dominating coconut tree plantations.

Because rice needs water to grow, next to these and the vegetable fields one can always find man-made ponds and small lakes which feature a wide habitat diversity. This rural system, though greatly transformed, has much value as a whole.

Human presence is made evident by the large number of foreign species to be found, such as *Catharanthus roseus* (Vinca, invasive plant from Madagascar) and *Mimosa pudica* (America).

	
Coconut tree plantation and other frui trees	Water pond
	
Rice field	Coconut tree plantation
	
Tapioca tamaño	*Prosopis juliflora*. A common small tree of Kanyakumari coast

Figure 24. Most representative vegetation species in the inner coastal fringe

3.3.1.1. Effects of the tsunami

A. Mascarenhas & S. Jayakumar (2008) carried out an endeavour to feel the pulse of a coast devastated by a the tsunami. Results of field investigations along Tamil Nadu seaside revealed that the tsunami of December 2004 demolished dwellings within strips ranging from 6 to 132 m (average width, 41 m) from the dune, and flooded up to 862 m (average, 247 m) from the shore. The event damaged sand dunes, ripped dune vegetation, created new water bodies and shattered high value assets. Comparatively, casuarina forests performed remarkably. Uprooting of trees was exclusively restricted to a frontal strip ranging from 5 to 25 m (average width, 14 m) nearest to the shore where the maximum wave run-up was 6.5 m above sea level.

Sand dunes in general, and casuarina forests in particular, posses an innate capacity to dissipate powerful waves. This inference is supported by: (a) negligible over wash along belts characterized by high dune complexes, (b) intact villages shielded by dense forests as well as sand dunes, and (c) maximum destruction of open beach front influenced by intense human activity. In this context, the Coastal Regulation Zone (CRZ) Notification of 1991 offers sufficient scientific validity to be endorsed.

3.3.1.2. Ecological importance of wetlands in the study area

Kanyakumari supports rich repertoire of wetlands, small and big, lentic and lotic, natural and manmade. These areas are occupied by aquatic and shore vegetation that establish strong association between aquatic and terrestrial ecosystems, and play a significant role in the primary production, nutrient cycling, and serve as bio indicators for eutrophication processes.
The common habitats of hydrophytes and marshy vegetation are in the ponds, tanks, rivers, dams, canal banks, ditches, low-lying water-logged areas, rice fields are ideal habitats for many aquatic, semi aquatic wetland and marsh plants . Seasonal puddles and ditches are scattered throughout the district, more commonly along the interior of the villages. They get filled up with water during the monsoon season and dry in a short period, while in others, water may persist for a considerably long time. In the forest, the hill swamps and streams support a different type of aquatic vegetation. In plains, the low-lying paddy fields form important habitat for hydrophytes of different groups.

In Kanyakumari district, almost all the water resources are occupied with various types of macrophytes viz. free floating, floating, submerged, rotted shoreline etc, which are an integral part of the ecosystem and act as bio-filters.

- Rare, endemic and threatened taxa

Based on Sukumaran et al. (2011), five rare, endemic and threatened species were collected during the present study. Two species namely Alocasia macrorrhizos and Kyllinga squamulata are the new distributional record for the flora of Tamil Nadu. The rare and endemic plants (Commelina hasskarlii, Cyrtococcum longipes, Indotristicha ramosissima and Eriochrysis rangacharii) have also been collected from the wetlands of the study area. The present collection clearly indicates that wetlands are conservation pockets of some rare and endemic plants.

3.3.1.3. Mangroves

Mangroves are of great ecological and economic significance and are among the most productive ecosystems. Because their high rate of production of organic matter, the mangrove are able to sustain a diverse community of organisms, ranging from bacteria to fishes, birds and mammals. Tamil Nadu has two major mangrove forests.

In the study area small patches of mangrove exists at Manakudi and Pantry (Rajakkamangalam) Estuary and Marshy land and as a results of a Mangrove Afforestation Program carried out by the Forestry Department.

3.3.2. Status of Faunal Diversity

3.3.2.1. Terrestrial fauna

The inland fauna has been greatly transformed by human activity, particularly due to the elimination of natural forest areas and scrubland, the high population density and the dominating cropland.Only low-density groups of small mammals and reptiles can live in these conditions.

Bird species are the most important and valuable group. Their presence is due to the bodies of water, lakes, canals, rivers and ponds in the area. The following sections on eco-sensitive areas describe the fauna in greater detail.

3.3.2.2. Sea turtle

The Indian Ocean offers a good environment as a habitat for turtles. Thus, the turtle can be regarded as the emblematic animal of the region. The feeding sites of turtles are coral reefs, lagoons and sea grass (a sort of marine prairie). The nesting period starts from October and last up to December end. The turtle start coming to the coast 20.00 hours continue until about 5.00 hours and maximum animal visit the beach during midnight. Rarely during the day time also the turtles visit the beach for nesting. They make nests much above the highest high tide level and scrap out sand to make the egg pit. They dig up to 50 cm depth for egg pit. Nesting behaviour in Kanyakumari is described by Mohan (1986).

Turtle fishing was practised in this region for ages and chelonians were exported to Sri Lanka and other countries until a couple of decades ago. Prior to 1972, there was legal live turtle trade between India and Sri Lanka.

Today there are seven species of marine turtles in the world. Although Kar and Bhaskar (1982) had reported the nesting of four species of sea turtles in Tamil Nadu (*Chelonia mydas* - green turtle; *Eretmochelys imbricata* - hawksbill; *Lepidochelys olivace*a - olive ridley; *Caretta caretta* - Loggerhead turtle) latest records indicate the nesting of only olive ridleys along the Tamil Nadu coast (Bhupathy and Saravanan 2006).

Nowadays sea turtle populations in this area have been reported to have declined due to their overexploitation for trade and from accidental drowning in fishing gear such as gillnets and trawlers Anti sea erosion measures affects the nesting beaches of marine turtles
Three most important nesting locations of olive ridleys were identified by Bhupathy and Saravanan (2006) in the GOI-UNDP 2000-2001 survey along the Tamil Nadu coast. This nesting sites are: Chennai, Mamallapuram - Pondicherry and Nagapattinam.

For Kanuakumari district based on different authors, mainly on Mohan (1998), in the 80´s decade it was estimated that on an average of about 4,000 turtles landed every year in the 73 km stretch of Kanyakumari coast. In 90´s there was a sudden drop in the annual landing and was estimated to be 1,000 turtles/year. For this author the sudden drop of turtles visiting this coast is due to the construction of sea wall and depletion of population.

Following figures shows the situation for 1998 of nesting sites of marine turtles and fishing villages of Kanyakumari district.

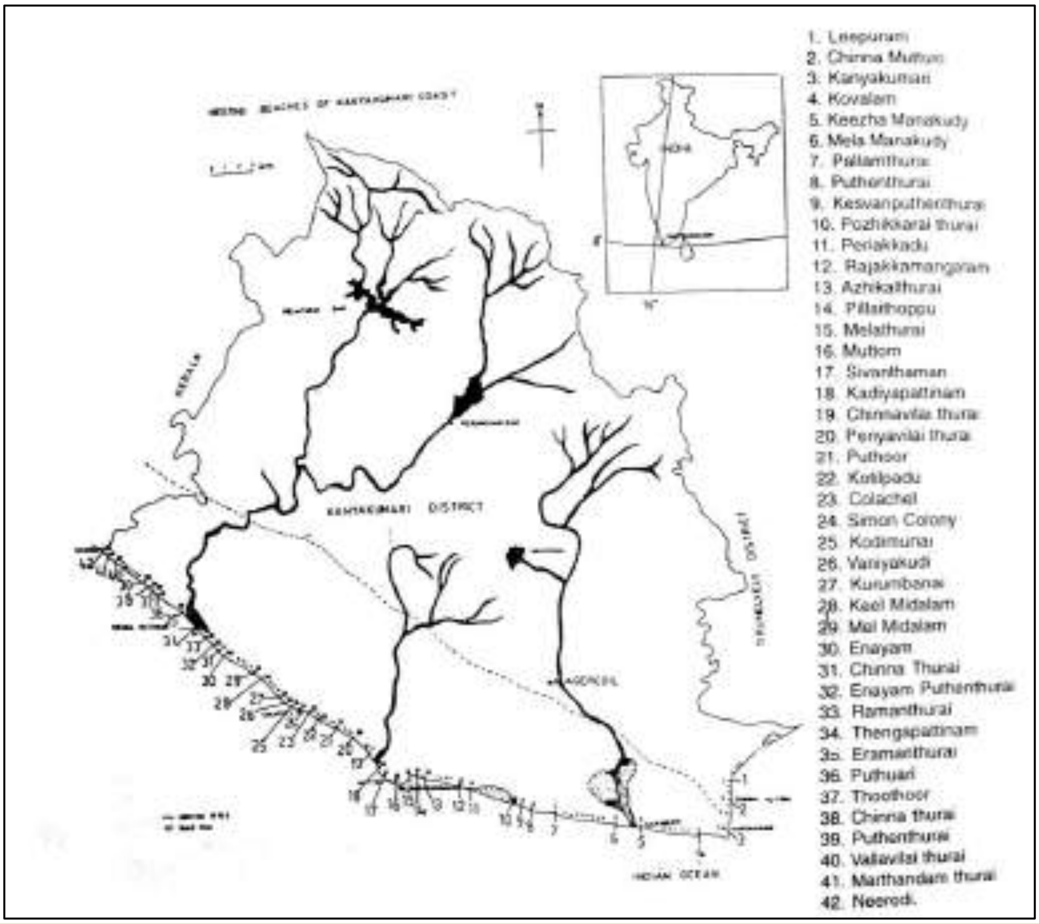


Figure 25. Nesting sites of marine turtles and fishing villages of Kanyakumari district. Source: *Lal Mohan 1998*

Natural calamities like the Tsunami of 2004, and cyclones have taken their toll on several areas of the Tamil Nadu coast, which is still evident in coastal areas of central Tamil Nadu. Global warming or climate change may also account for this, as fishermen have witnessed an increase in water level which has reduced nesting areas in the southern coast. Sand mining in the southern coastal districts has also reduced nesting beaches. Casuarina plantations, which reduce beach space for nesting, are quite prominent along the Kanyakumari coast (WWF-India 2013)

Turtles choose sandy beach sections and avoid rocky areas. They prefer beaches with a sandy backshore which can be easily accessed; that is with no steps or barriers or dense tree or shrub vegetation which may make it difficult to dig a nest. For instance, the beach section between. Muttom and Manavalakurichi would not be suitable, nor would receding beaches with sharp escarpments, beaches with casuarina plantations or without a sandy transition area, with coconut tree plantations or cropland. Based on GROYNE- FIELD concept, a series of groynes have been constructed and proposed along the Kanyakumari coast for reducing severe attacks of sea wind- tides due to rough weather into the lands and preventing heavy erosion.
These coastal protection structures affect the district beaches' natural ability to harbour marine turtle nests. For this reason, the rock walls in many beaches in Kanyakumari have made them unsuitable for turtle nesting. Ios. There are, however, some acceptable beach sections. These are located south and north of Manakudy and near

Rajakkamangalam (15 to 20 olive turtle nests in 2014) and further north between Thengapattinam and Eramanthurai.

These locations can be seen in the following image.

Figure 26. Suitable sea turtle nesting beaches

Figure 27. Rajakkamangalam beach. Sea turtle nesting on the beach. Sea turtle conservation campaign. 2014. *Pictures courtesy of Conservation of Nature Trust, Nagercoil, Lal Mohan.*

3.3.3. Eco Sensitive Areas

3.3.3.1. Suchindram Therur and Vembanoor wetlands

The Suchindram Theroor Birds Sanctuary and Important Bird Area (IBA IN279) is a protected area comprising the Suchindram Kulam wetlands.
Suchindram is noted for the wide variety of migratory water birds that winter there, including: near threatened painted stork and spot-billed pelicans. Also seen here are cattle egrets, great cormorants, darters, purple

swamphen, and bronze-winged jacanas. Resident raptors include pied kingfisher, brahminy kite and marsh harrier. Other water birds are dabchick, grey heron, garganey, purple heron, cinnamon bittern, open bill stork, cotton pygmy goose, whiskered tern and little tern, black-winged stilt, greenshank, little ringed plover and the common sandpiper. This important area corresponds to the Manakudy estuary formed by the confluence of river Pazhayar in between East and West Manakudy villages

The history of these natural tanks is age old, but it is known that kings contributed a great deal to the irrigation facilities. Copper plate inscriptions from the 9th century mention Pasumkulam; Venchikulam; Nedumarthukulam; Perumkulam; Elemchikulam and Konadunkulam. The Pandyan king Veeranarayana was known to have had some of the tanks constructed. Veeranarayana Mangalam is named after King Veeranarayana; who built the Therrakal canal to take water from River Pazhayar to the tanks Thathiarkulam; Puthukiramamkulam and Theroorkulam. The famous Suchindram tank was built about 1000 years ago. It is fed from the Kumari Dam constructed across Pazhayar (also called Palayar) below Sabari Darn. The Sabari and Kumari Dams may be more than 1000 years old. The River Pazhayar collects the entire drainage of the valley and irrigates a substantial part of Nanchilwadu. The main Pazhayar strearn passes through Bhuthapandi-kottar; Thazhakudi and Suchindram tanks and enters the Manakudi estuary. These tanks were located towards Tiruneveli district.

- Key Biodiversity
    - Avifauna

About 250 species of birds have been recorded in the district of which 53 species are migratory; twelve are endemic and four species threatened (Balachandran 1998). Birds such as Spotbilled Pelican *Pelecanus philippensis,* Darter *Anhinga melanogaster,* Northern Pintail *Anas acuta,* Common Teal *Anas crecca,* Spo tbill Duck *Anas platyrhynchos,* Garganey *Anas querquedula* and Common Coot *Fulica atra* congregate in these tanks, sometimes in thousands. has counted huge flocks of Garganey, just before their return migration in March. One flock consisted of nearly 30.000 individuals.

    - Other key fauna

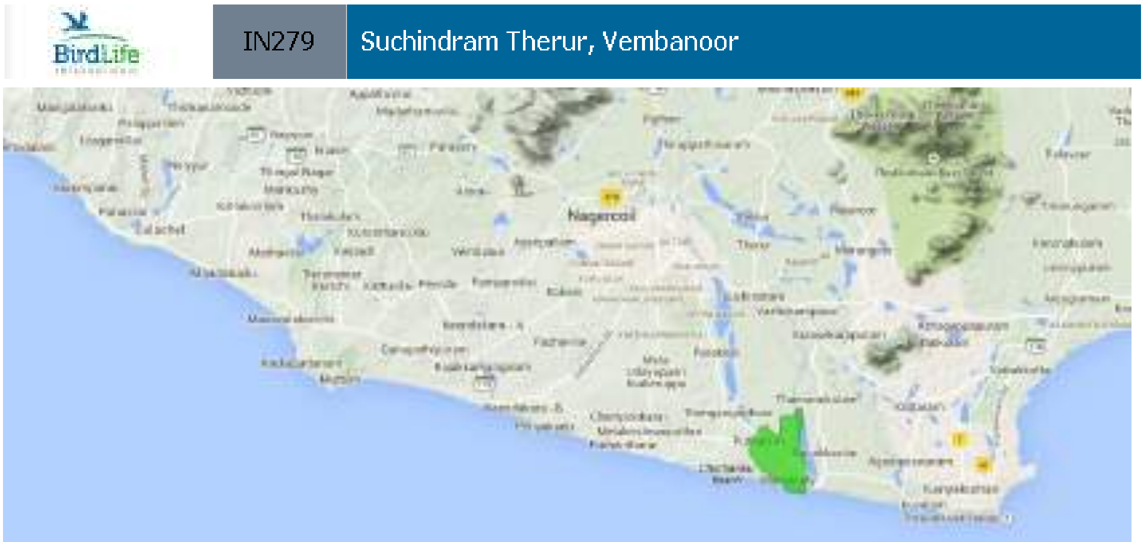


Figure 28. Important Bird Area (IBA), IN279; Suchindram Therur, Vembanoor wetlands

As these wetlands are surrounded by human habitations and agricultural fields, there are no wild large mammal. Various species of commercial fish are found. *Tilapia* has been introduced that has destroyed small native fish.

Species	Season	Period	Population estimate	Quality of estimate	IBA Criteria	IUCN Category
Garganey *Spatula querquedula*	-	2004	present	-	A4i	Least Concern
Spot-billed Pelican *Pelecanus philippensis*	resident	2004	present	-	A1	Near Threatened

Figure 29. Population of Suchindram Therur, and Vembanoor wetlands, trigger species

3.3.3.2. Other ecological sensitive areas

All of them are estuaries and coastal lakes linked to rivers. Estuaries are important buffer zones as it is a transition zone between freshwater environments and are subject to marine influences such as tides, waves and influx of saline water, fresh water and sediment. This inflow of both marine and fresh water brings lots of nutrients in both water and sediment makes them most productive habitats in the world. They are also important for their bird fauna. An important part of the bird community in the Kanyakumari district lives around these coastal bodies of water..

- Thengapattinam estuary, also a CRZ-I site.
- Valliyar estuary near Kadiapattinam.
- Manakudy estuary in between East and West Manakudy villages, also a IBA site
- Two minor estuaries also: they are
  - Pambar estuary near Colachel
  - Pantri estuary near Rajakkamangalam.

Pantry (Rajakkamangalam) Estuary and Marshy land contains a Coastal ecosystem, sand dunes and Sea turtle breeding site near Azhathangarai beach. Rajakkamangalam estuary and Azhathangarai marshy land is considered as one of the breeding and feeding ground for many birds like Painted stork, cormorant, spot billed pelicans, purple swaphen, dabchick, garganey, purple heron, open bill stork ,black winged stilt etc

Figure 30. Eco Sensitive Areas: 1. Thengapattinam estuary; 2. Pambar estuary- Colachel; 3. Valliyar estuary - Manavalakurichi; 4. Pantri estuary - Rajakkamangalam; 5. Manakudy estuary ; 6. Valkulam

3.3.4. Marine Ecology

Coastal ecosystems have key inbuilt features or functions. The ecosystems involving in primary and secondary production, sustain the flora and fauna, store sediments and organic carbon, essential to the maintenance of food chains. The coastal ecosystems provide foods (fish, oil, gas, minerals) and services (natural defence against storms and tidal waves, recreation and transportation). The coastal ecosystems provide habitat to genetically, ecologically and economically valuable biological organisms. Out of 71 phyla encompassing all forms of life, 43 phyla are in the oceans.

A significant element of these resources consists of clupeoid fishes with short food chains. We have the well known examples of the Peruvian anchoveta and the California sardine on the west coast of the Americas and the Pilchard on the south west coast of Africa.

Kanyakumary district (Tamil Nadu) and Kerala State, situated on the south- west coast of the Indian subcontinent is also known for its fish wealth dominated by the oil sardine. The basic factor favouring the high productivity in all these areas is the phenomenon of upwelling and the production cycle triggered by this.

The shelf is relatively narrow, the distance from the shore to the shelf edge ranging from about 30-50 miles, being narrow in the south (Kanyakumari South) and broad in the north (Kerala State). In the south of the Indian south west shoreline the sea bottom is hard and quickly sloping and muddy or sandy with gentle sloping seawards.

3.3.4.1. Oceanographic Characteristics

During the monsoon, the southerly current spreads over the entire continental shelf. Isolines of water temperature, salinity, dissolved oxygen (DO), and density rise to the surface due to upwelling and occupy the area between the southerly current and the coast. Consequently, dense and cool water with low DO occupies the surface near the coast. During the post-monsoon period (October-January), there is a strong current with northerly flow. On the seaward side of the flow, there is a southerly flow, but only in the southern region of the southwest coast. During this period, the low salinity equatorial waters are advected northwards, causing sinking of high salinity Arabian water below the equatorial waters between 10° and 12° N latitude. During the pre-monsoon period (February-May), the northerly current disappears and the southerly flow is restricted to a narrow belt.

During the monsoon, the thermocline reaches the surface and the average sea surface temperature is around 24° C. During the post-monsoon period, the thermocline descends from the surface (October-November), and reaches deep waters (December-February). During the pre-monsoon, the thermocline remains deep, and the average surface water temperature increases to about 30° C.

During the monsoon, the mean sea surface salinity is relatively low (32.5 ppt) due to river runoff and the salinity maximum (35 ppt) occurs at 30 - 50 m depth. During the post-monsoon, the sea surface salinity is 33 ppt in the southernmost sector of the southwest coast off Cape Comorin and increases northwards up to Karwar (about 35 ppt). During the pre-monsoon period, as the temperature is high, the salinity also remains high in the entire shelf with mean surface salinity of 36 ppt. Oxygen-deficient water starts penetrating the shelf by May, and covers the entire bottom by June-July. By August, the oxycline becomes shallow and reaches the surface where it remains till September-October. It has been observed that the oxycline remains for a longer duration in the northern sector of southwest Indian coast than in the southern. However, the DO level is higher in the northern sector as the intensity of upwelling is low. During November-April, the shelf water is well aerated and the mean DO is 4.5 to 5.0 ml·L-1.

Due to upwelling during the southwest monsoon, the southwest coast is characterized by a high level of nutrients such as phosphate, nitrate and silicate in the surface waters. The nitrate content in the surface waters is very high (3 to 4 µM) compared to < 1µM during the other months, which results in high productivity of 660 mg C·m-2·day-1 compared to 200 mg C·m-2·day-1 during the other months. The plankton biomass is significantly higher (0.9 to 1.2 ml·m-3) compared to < 0.5 ml·m-3 during the other months. The rate of primary production in the neritic waters, for instance, is as high as 1 g C m-2·day-1 during upwelling compared to only 0.1 g C·m-2·day-1 during the other seasons. The phytoplankton production along the south-west coast shows a strong north-south gradation, (Fig. below). The pictures cover 3-months periods starting from December 1997 through November 1998. The scale ranges from 0 (gray) to 150 (white) g C·m-2·month-1.Source: Trophic Model of the Coastal Fisheries Ecosystem of the Southwest Coast of India E. Vivekanandan, M. Srinath, V.N. Pillai, S. Immanuel and K.N. Kurup Central Marine Fisheries Research Institute (CMFRI),The Indian Council of Agricultural Research (ICAR).

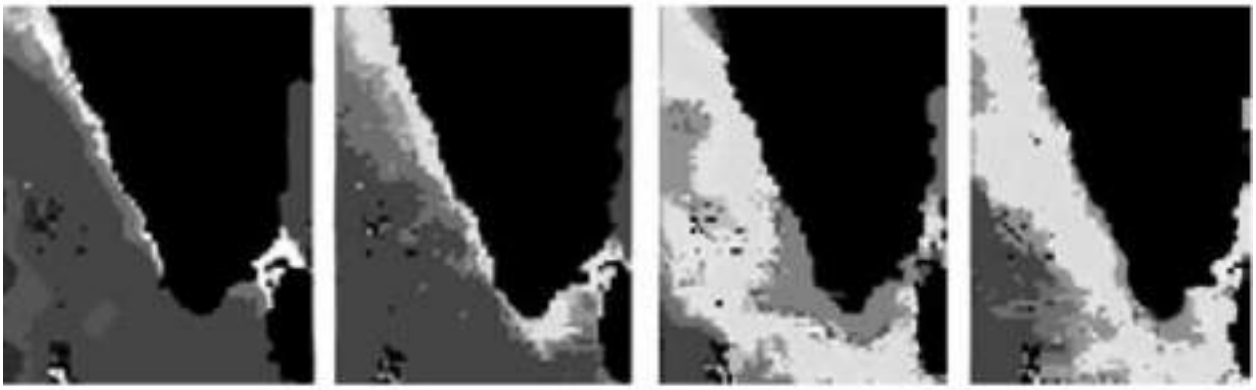


Figure 31. Primary productivity along the southwest coast of India.

The production increases from 0.1 g C•m_{-2} •day_{-1} off Goa to > 1 g C•m_{-2}•day_{-1} off Cochin. In general, the southwest coast is rich in phytoplankton and zooplankton biomass compared to the other Indian coastal waters.

The seas of south-west India, particularly south of Kerala end Kanyakumari (Tamuilnadu) has the unique feature of receiving discharge from a number of small and medium rivers and harbouring an even large number of estuaries and backwaters. This coupled with the monsoons and other natural process make this coast the home for an unlimited number of fin fishes and shell fishes.

3.3.4.2. Fishing Grounds

The major fishing grounds of south-west India coast are Wadge Bank Quilon Bank and Chettuva Bank.

3.3.4.2.1 Wadge Bank

Wadge bank is a fertile fishing found where rich marine biological diversity occurs. Wadge bank may also be defined as a place of marine environment. Where rich availability of fish food organisms is available. The water depth of this region is low. The physical features of the water like under water current, tides and waves will have less impact on the fishes and animals of this region. Fishes select this region for feeding and breeding purposes. Throughout the maritime countries of the world there are about twenty such wadge banks. Of these one is situated near Kanyakumari on the coastline of Kanyakumari District on the eastward as well as on the westward region for about 30 Km. Here representatives of fish species of the three seas are occurring.

The continental shelf at the southern tip of India extends about 50 miles from Cape Camorin sloping gently from a depth of 10 fathoms close to shore to 50 fathoms, after which it plunges to abysmal depths. The portion between E. longitude 77° and 78°10′ is popularly known as "Wadge Bank", an area of approximately 3,000 square miles. The eastern half of the Bank is flatter and shallower (average depth about 22 fm) than the western (average depth about 36 fm) and its edge drops off more suddenly to extreme depths.

Coarse yellow sand overlaying flat rocks, is common out to the 30-fathom contour. Beyond this to the edge of the continental shelf, the bottom is made up of firm, clear sand with stretches of flat rock. There are some muddy areas but these are of relatively small extent. These are not charted but their positions are known now to the fishing skipper and avoided.

The ground then was rougher with many sea fans (Gorgonids) and sponges which interfered with trawling and handling of catches, but these have been slowly removed and do not seem to have recovered their growth. They are more prevalent in the deeper parts of the bank that are not regularly fished. It has further been reported that stones, coral lumps can break the nets

The peak of the season for this ground is from July to October. The trawl catches then consist of sea bream. Rock cod, red snapper, blue spotted snapper, sharks, paraw(kingfish), cat fish yeela, orawa pathupara and other varieties. From October through June the catches consist of sea bream, rock cod, red snapper, blue spotted snapper and skates.

3.3.4.2.2 Quilon Ground.

Located between Cochin and Cape Comorin. The bottom conditions on this ground are favourably good with the exception of a few places west and south west of Quilon. This is a typical all year fishing ground except during the south west monsoon from May to September. The catches consist mainly of mixed fish, but shrimp are found off Quilon in December, January, March and April. Shrimp are also found at the north east part of the ground. It seems that there is migration from the southern part to the northern during these months.

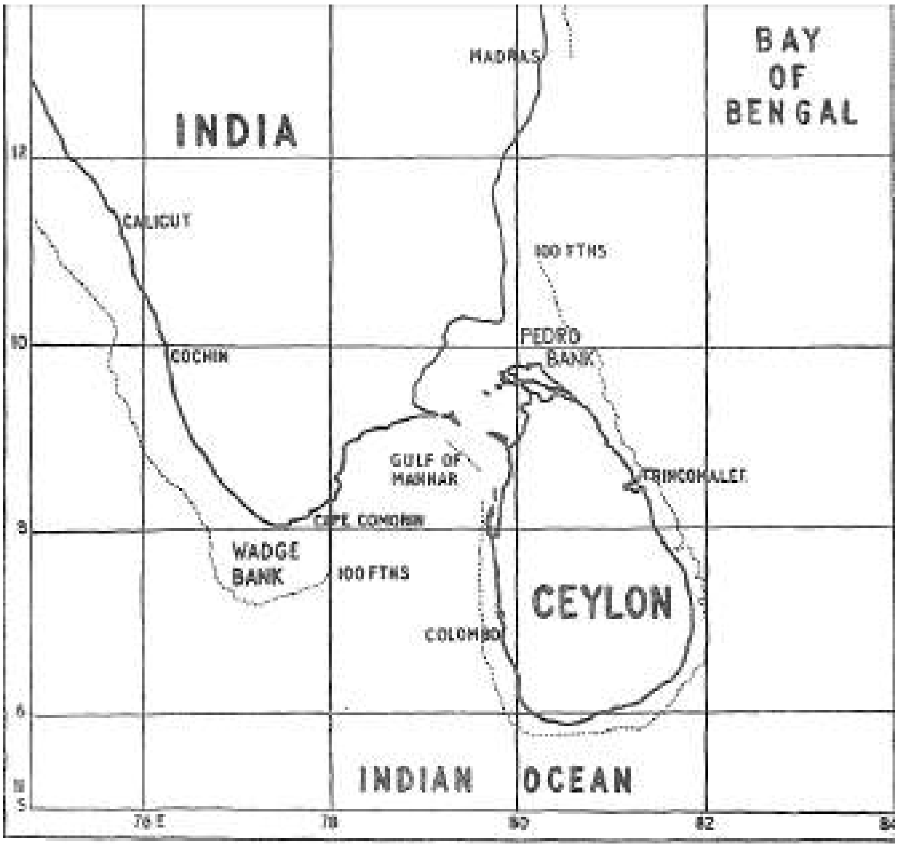


Figure 32. Wadge Bank. Source: Sivalingam 1957

3.3.4.3. Estuarine Ecosystems

As is mentioned in other chapter, another major feature of the coastal zones is the presence of a large number of backwaters and canals. These are estuaries and lagoons which are mostly interconnected by natural or man-made canals.

There are three important riverine ecosystems, which confluence with Arabian Sea in Kanniyakumari

Thengapattinam estuary, formed by the confluence of river Tampirabarani in between Thengapattinam and Eraiummanthurai.

- Valliyar estuary formed by the river Valloiyar near Kadiapattinam.
- Manakudy estuary formed by the confluence of river Pazhayar in between East and West Manakudy villages.

Apart from these are two minor estuaries also: they are

- Pambar estuary near Colachel and
- Pantri estuary near Rajakkamangalam.

These are formed by the drainage canal excess waste during monsoon and the water drained from the irrigational fields mixing with sea.

3.3.5. Marine biocenosis

The following information was obtained from: Trophic Model of the Coastal Fisheries Ecosystem of the Southwest Coast of India. E. Vivekanandan, M. Srinath, V.N. Pillai, S. Immanuel and K.N. Kurup. Central Marine Fisheries Research Institute (CMFRI). 2003.

- Primary Production

Phytoplankton primary production has been estimated along the southwest coast by several researchers. The average production in the neritic waters is estimated to be 0.5 g C·m-2·day-1 (Pant 1992). A conversion factor of 0.06 g C = 1 g wet weight (Walsh 1981) was employed for transformation. Average total primary production for the ecosystem was estimated as 3042 t·km2·year-1.

Large Predators

The large predators include sharks, seerfishes, tuna and billfishes. The dominant species of shark along the SW coast are the large-sized Carcharhinus spp. and Rhizoprionodon acutus and the smaller Scoliodon laticaudus.

- Medium Predators

The medium predators include the lizardfish Saurida tumbil, major perches such as snappers (Lutjanus spp.), pig-face breams (Lethrinus spp.), ribbon fishes (Trichiurus spp., Lepturacanthus savala), barracudas (Sphyraena spp.) and cephalopods (Sepia pharaonis, Sepia elliptica, Sepiella inermis, etc.

Large Zoobenthic Feeders

The large zoobenthic feeders include skates, rays, eels, groupers (Epinephelus spp.) and Indian halibut (Psettodes erumei). Though this group is a major predator on demersal feeders such as threadfin breams and croakers, available information suggests that plankton feeders such as the Indian mackerel, which descend to the bottom and contribute to the trawl catches, constitute the major part of the diet.

- Demersal Feeders

The *demersal* fish groups such as the threadfin breams, croakers, silverbellies and pomfrets constitute this group. The demersal feeders consume large quantities of plankton feeders (0.75), mesopelagic feeders (0.15) and detritivores (0.05).

- Mesopelagic Feeders:ñ

  This ecological group includes the carangids such as Caranx spp., Alepes spp., Selar spp., Chorinemus, the horse mackerel Megalaspis cordyla, the wolf herring Chirocentrus spp, half beaks and full beaks. They feed mainly on the plankton feeders (0.80), zooplankton (0.14) and detritivores (0.05)

- Molluscan Feeders

The crabs Portunus spp. and Charybdis spp. and the spiny lobsters Panulirus spp. feed primarily (0.75) on bivalves such as the mussels and clams

- Plankton Feeders

The plankton feeders are mostly small pelagics such as the clupeids Sardinella spp., Stolephorus spp. and Thryssa spp.; the scads Decapterus spp. and the Indian mackerel Rastrelliger kanagurta contribute the maximum biomass to the southwest ecosystem. The information on the diet composition of the small pelagics has been reviewed by (Devaraj et al. 1997). The lesser sardines Sardinella fimbriata and Stolephorus devisi feed primarily on phyto-plankton whereas S. gibbosa and S. bataviensis (S. waitei in FishBase 2000) feed mainly on zooplankton.

Ontogenetic changes in the feeding habits are also observed in several species. The oil sardine S. longiceps, for instance, feeds on diatoms and microalgae when it is a postlarva, on zooplankton when it is a juvenile, and once again on diatoms after becoming adult. The mackerel R. kanagurta feeds on zooplankton when it is a juvenile, and on phytoplankton after becoming adult. Thus it is difficult to categorize such species as exclusive phytoplankton feeders or zooplankton feeders. Nevertheless, it is considered that phytoplankton and zooplankton constitute a major share (0.94) in the diet of this ecological group, and the juveniles of the plankton feeders themselves contribute the rest.

- Detritivores

The penaeid and non-penaeid prawns and the mullids are categorized as the detritus feeders. The detritivores feed almost exclusively on detritus (1.0). They are preyed upon by several ecological groups. Moreover, the penaeid prawns are a target group for the commercial fisheries.

- Zooplankton

This group includes mostly copepods and fish larvae. The zooplankton biomass was estimated as 10 t·km-2.

		
Oil sardine. Sardonella longiceps	Indian mackerel Rastrelliger kanagurta	Thryssa sp.
		
Group of Snappers, croackers and breams	Ribbon fish (Lepturacanthus savala) and Thryssa sp.	Shark and guitar fish . Rhincobatus djeddensis

Figure 33. Commom fish species

3.4. SOCIECONOMIC AND OCCUPATIONAL HEALTH ENVIRONMENT

3.4.1. Scope and Methodology

To assess the existing socio-economic condition of the study area, information was collected both from secondary sources and primary data collection through field surveys, Focus Group, Discussions and Consultations (FGD) with key stakeholders

3.4.2. Secondary Information and Data Collection

Secondary socio-economic sources included various published documents like the Economic Review (2011) of Tamil Nadu State Planning Board, CCC Bussines Plan for Colachel , Marine Fisheries Census Data Tamil Nadu (2010)CMFRI, the official websites of Kanyakumary District and so forth.

3.4.3. Primary Data Collection

The primary data collection and consultations were carried out with the objectives of:

- Assessing the socio-economic situation of the local people
- Creating public awareness about the project
- Assessing the views of local people about the project
- Understanding the needs of the community for possible incorporation into community development plans.

The approach and methodology adopted for primary data collection is described below:

- First, a detailed desk review of reports and secondary data related to the socio-economic context of the project was undertaken.

- Reconnaissance visits to the project site were made and screening of potential social impacts in the study area was carried out. During these visits, public consultations were conducted to gather feedback from the local people on the proposed development and its perceived socio-economic impacts.
- Various meetings and consultations with relevant Government departments were conducted.
- Stakeholder identifying and consultation
- Sample size was finalised by using population data of the area from the 2001 census and also by visiting all the Panchayats, collecting relevant information related to census of the villages which may be affected by the proposed project.

3.4.3.1. Baseline Survey

Baseline survey on sample basis was conducted from March 17 – April, 2 2015 to collect study area specific information and to understand the baseline socio-economic conditions. The following socioeconomic issues were covered as part of the baseline survey:

- Demographic characteristics:
- Social characteristics:
- Economic profile:
- Service infrastructure, ,
- Other Infrastructural facilities, including the fishing harbour and local small scale industries
- Cultural heritage and practices: Includes archaeological monuments and cultural/ traditional
- practices.

3.4.4. Brief Socioeconomic profile of the Kanyakumari District

Kanyakumari is the southernmost district of Tamil Nadu. The district lies between 77 15' and 77 36' of the eastern longitudes and 8 03'and 8 35' of the northern Latitudes. The District is bound by Tirunelveli District on the North and the east. The South Eastern boundary is the Gulf of Mannar. On the South and the South West, the boundaries are the Indian Ocean and the Arabian Sea. On the West and North West it is bound by Kerala. With an area of 1672 sq.km. it occupies 1.29% of the total extent of Tamil Nadu.

The area comprising the present Kanniakumari district was a part of the erstwhile Travancore state. In 1835, when the state was divided in to Northern and Southern divisions , this area formed part of Southern division and was placed in the charge of Dewan Peishkar, Kottayam. In July 1949, when the United States of Travancore and Cochin was inaugurated, the present Kanniyakumari area continued to be a part of Trivandrum district of Kerala State.

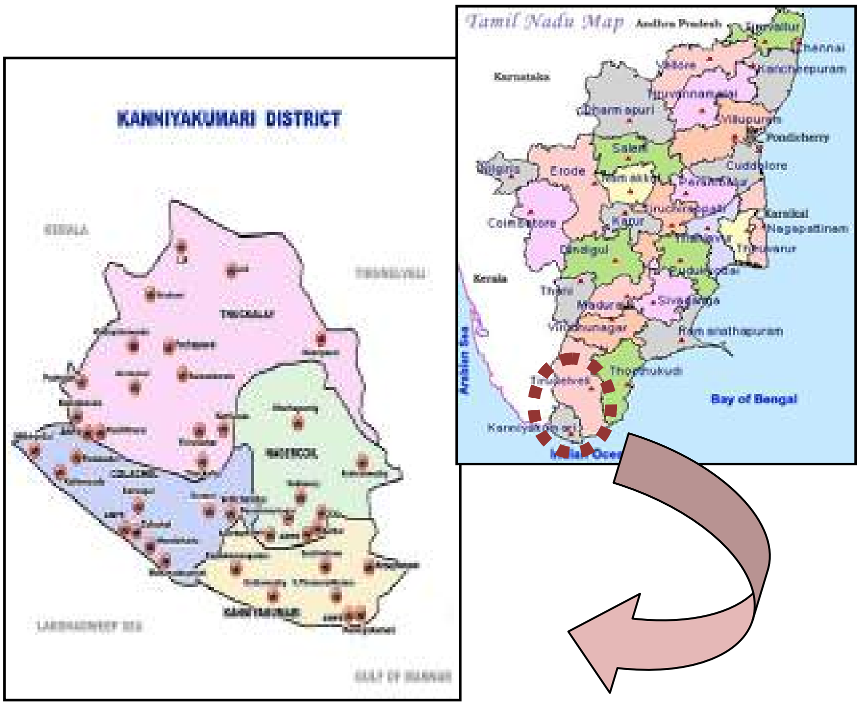


Figure 34. Kanyakumari Distric

Kanyakumari District	Taluks	Blocks	Municipalities	Town panchayats	
	Agastheeswaram Kallkkulam Thovalai Vilavancode	Agastheeswaram Killiyoor Kurunthancode Melpuram Munchirai Rajakkamangalam Thiruvattar Thovalai Thuckalay	Colachel Kuzhithurai Nagercoil Padmanabhapuram	Alur Anjugramam Aralvaimozhi Arumanai Asaripallam Attoor Azhagappapuram Azhagiapandiapuram Boothapandi Edaikodu Eraniel Ezhudesam Ganapathipuram Kadayal Kaliyakkavilai Kallukuttam Kanyakumari Kappiyarai Karungal Keezhkulam Killiyur Kodimunai Kollancode Kothanalloor Kottaram Kulasekaram Kumarapuram Manavalakurichi Mandaikadu	Marthandam Marungoor Mulagumudu Myladi Nallur Neiyyur Pacode Palapallam Pazhugal Ponmanai Puthalam Pudukadai Reethapuram South Thamaraikulam Suchindram Thalakudi Thengampudur Theroor Thingalnagar Thiruparappu Thiruvattar Thiruvithamcode Unnamalaikadai Valvaithankoshtam Vellimalai Verkilambi Vilavoor Villukuri

Table 8.: Administrative organisation of Kanyakumari District

3.4.4.1. Population

The States Reorganisation Commission also recommended this. Accordingly, the States Reorganisation Act, 1956 was passed and the Kanyakumari District was formed on 1st November 1956 , with the four Taluks, Viz., Agasteeswarem, Thovalai, Kalkulam and Vilavancode and merged with Tamil Nadu. Thiru. R .Thirumalai I.A.S assumed charge as the first Collector of Kanniakumari District on 01.11.1956. The population of Kanyakumary

(Agasteeswarem, Thovalai, Kalkulam and Vilavancode Taluks) which formed the southern divisions of the former Trivandrum District, were predominantly Tamil speaking. They agitated for the merger of this area with Madras State. Tamil and Malayalam are the main languages of this district. Hindus and Christians form a sizeable percentage of the population of the district and there are a number of Muslims dominated belts in the district. The caste system in the Society has weakened to a great extent especially after independence because of growth of education and improvements in transport and communication. Some of the communities in the district are Nadars, Nanjil Nadu Vellalars, Paravas, Mukthavas, Vilakki Thalanayar, Kammalar or Asari, Nairs, Chackarevars, Kerala Mudalis etc.

As of the census of India 2001, Kanniyakumari had a population of 19,739 comprising 9,884 males and 9,855 females, making the sex ratio (number of females per thousand males) of the town to 997. A total of 2,403 people were under six years of age and the child sex ratio (number of females per thousand males under six years of age) stood at 1,024. The town had an average literacy of 88.62%, higher than the national average of 59.5%. A total of 269 comprising 1.55% of the population belonged to *Scheduled Castes* (SC) and 169 comprising 0.97% of the population belonged to *Scheduled tribes* (ST). There were are total of 4,236 households in the town.

SL No.	Name of the Blocks/ Municipalities	Area (sq.km)	Population			Literate		
			Persons	Male	Female	Persons	Male	Female
1	2	3	4	5	6	7	8	9
1	Agastheswaram	133,12	148419	73260	75159	118778	60120	58658
2	Rajakkamangalam	120,16	137254	68119	69135	108539	55337	53202
3	Thovalai	369,07	110719	55057	55662	85132	44101	41031
4	Kurunthancode	106,85	165070	81823	83247	126882	64369	62513
5	Thuckalay	130,33	167262	82488	84774	131428	66461	64967
6	Thiruvattar	344,8	161619	80220	81399	122710	62524	60186
7	Killiyoor	82,7	156387	78663	77724	119931	62173	57758
8	Munchiri	72,01	177225	89122	88103	131461	68366	63095
9	Melpuram	271,89	179535	88578	90957	137211	70560	66651
10	Nagercoil Municipality	24,27	208179	102907	105272	175248	88590	86658
11	Padmanabapura mMunicipality	6,47	20075	9967	10108	16282	8372	7910
12	Colachel Municipality	5,18	23787	11996	11791	18008	9275	8733
13	Kuzhithurai Municipality	5,15	20503	10069	10434	16712	8419	8293
	TOTAL	1672	1676034	832269	843765	1308322	668667	639655

Table 9: Kanyakumary area and Population. *Source: Census of India*

Out of the total Kanyakumari population for 2011 census, 82.33 percent lives in urban regions of district. In total 1,539,802 people lives in urban areas of which males are 761,407 and females are 778,395. Sex Ratio in urban region of Kanyakumari district is 1022 as per 2011 census data. Similarly child sex ratio in Kanyakumari district was 966 in 2011 census. Child population (0-6) in urban region was 148,570 of which males and females were 75,573 and 72,997. This child population figure of Kanyakumari district is 9.93 % of total urban population. Average literacy rate in Kanyakumari district as per census 2011 is 91.96 % of which males and females are 93.92 % and 90.06 % literates respectively. In actual number 1,279,358 people are literate in urban region of which males and females are 644,109 and 635,249 respectively.

As per 2011 census, 17.67 % population of Kanyakumari districts lives in rural areas of villages. The total Kanyakumari district population living in rural areas is 330,572 of which males and females are 164,938 and 165,634 respectively. In rural areas of Kanyakumari district, sex ratio is 1004 females per 1000 males. If child sex ratio data of Kanyakumari district is considered, figure is 957 girls per 1000 boys. Child population in the age 0-6 is 33,780 in rural areas of which males were 17,262 and females were 16,518. The child population comprises 10.47 % of total rural population of Kanyakumari district. Literacy rate in rural areas of Kanyakumari district is 90.76 % as per census data 2011.

Gender wise, male and female literacy stood at 92.39 and 89.16 percent respectively. In total, 269,380 people were literate of which males and females were 136,432 and 132,948 respectively.

3.4.4.2. Natural resources and productive sectors

Basically Kanyakumari district is an agrarian economy. The demand for land for purpose other than agriculture is continuously increasing. Land in the district has acquired new dimensions with economic development. The hectic infrastructural developments like road, railways, transport, educational institutions and industries have increased the residential requirement. Changing life-style of the people is competing with agricultural usage of land.

Kanyakumari Forest Division forms the southern part of Agasthiamalai region and is located between the Neyyar Wildlife Sanctuary of Kerala and the KalakkadMundanthurai Tiger Reserve of Tamil Nadu. It encompasses the southern most forest tracts of the Western Ghats. The tract has its significance in possessing peculiar types of micro-habitats due to its geographical location, physical structure and varying altitudes. At Varaiattumudi, the Western Ghats ridges turn almost towards east until it reaches the Mahendragiri peak and again continues towards south in scattered hillocks until it reaches ground level at Nilapparai near Vattakottai. Moreover, the Kanyakumari Forest Division has a peculiar constitution of the eastern, western as well as southern slopes of the Western Ghats into its territory.

The general climate of sanctuary is pleasant. Both the south-west and north-east monsoon winds, the proximity of the sea and the dwindling heights of Western ghats greatly influence the climate. In Kanniyakumari rainfall is distributed over four seasons, (a) south-west monsoon (June-Sept) 37 % and 33.7 rainy days (b) northeastmonsoon (Oct- Dec) 37.9% and 26.5 rainy days, (c) winter (JanFeb) 2.7% and 2.7 rainy days and (d) the hot weather summer seasons 21.7 % and 16.8 rainy days.

In the hill region the rainfall is uniformly distributed in both monsoons and maximum rainfall occurs during October and November. On the whole this district gets an average annual rainfall of 1369.5 mm with 79.7 rainy days.

The District has a favourable agro-climatic condition, which is suitable for growing a number of crops. The proximity of equator, its topography and other climate factors favour the growth of various crops.The paddy varieties grown in the second crop season in Thovalai and Agasteeswaram taluks are grown during the first crop season in Kalkulam and Vilavancode taluks.

This shows that there is distinct variation in the climatic conditions prevailing within the district. Unlike other district in Tamil Nadu, it has a rainfall both during the South West and the North East monsoons.
The South West monsoon period starts from the month of June and ends in September, While the North East monsoon period starts from October and ends in the middle of December.

S No	Classification	2010-11	2011-12
1	Forest	4772.30	4772.30
2	Barren and uncultivable waste	4000.831	4000.831
3	Land put to non-agri use	28409.038	28487.935
4	Cultivable waste	101.725	83.055
5	Permanent pasture and other grazing land	103.600	103.600
6	Land under miscellaneous tree crops not included under net area sown	733.480	623.653
7	Current fallows	428.739	644.455
8	Other fallow lands	476.122	577.140
9	Net area sown	78791.434	78524.300
	Total	**117816.999**	**117816.999**
	Unclassified forest	11305.000	11305.000
	Reserve forest	38078.000	38078.000
	Total geographical area	**167199.999**	**167199.999**

Table 10: Land Utilisation in Kanyakumary

3.4.4.2.1 Agriculture and Irrigation

Agriculture and irrigation systems in Kanyakumari depends on the geomorphology and rainfall availability. Based on the agro-climatic and topographic conditions district can be classified into three regions :

- The Uplands : Comprising of hills and hill bases suitable for Growing crops like Rubber, Cloves, Nutmeg, Pepper, Pineapple etc
- The Middle : Comprising of plains and valleys fit for growing crops like Paddy, Tapioca, Banana, Coconut etc.
- The Lowlands :Comprising the coastal belt ideal for growing Coconut, Cashew etc.

The major river in the district is *Thamirabarani* locally known as Kuzhithuraiar. This river has two major tributaries, Kodayar and Paralayar, with the *Pechiparai Dam* and *Perunchani Dam*, respectively, built across them. There are many tributaries for the Kodayar River of which *Chittar* I and Chittar II, with their dams, are the major ones. The origin of Tambaraparani River is in the *Western Ghats* and the river confluences with *Laccadive Sea* near Thengapattanam, about 56 kilometres (35 mi) west of Kanyakumari town. The water of the Pechiparai is taken along the left bank canal to Puthen dam across the Paraliyar. Puthen dam is the main head works of the entire system when water of the Pechiparai and Perunchani meet. At the head works, these waters are flown into Pandiankal and Padmanabhapuram Puthanar. The Pandiyankal after running for about 2.5 Km. forks into two at Chellanthurithy. One of the left side called the Thovalai Channel and the other on the right side called the Regulator kal.

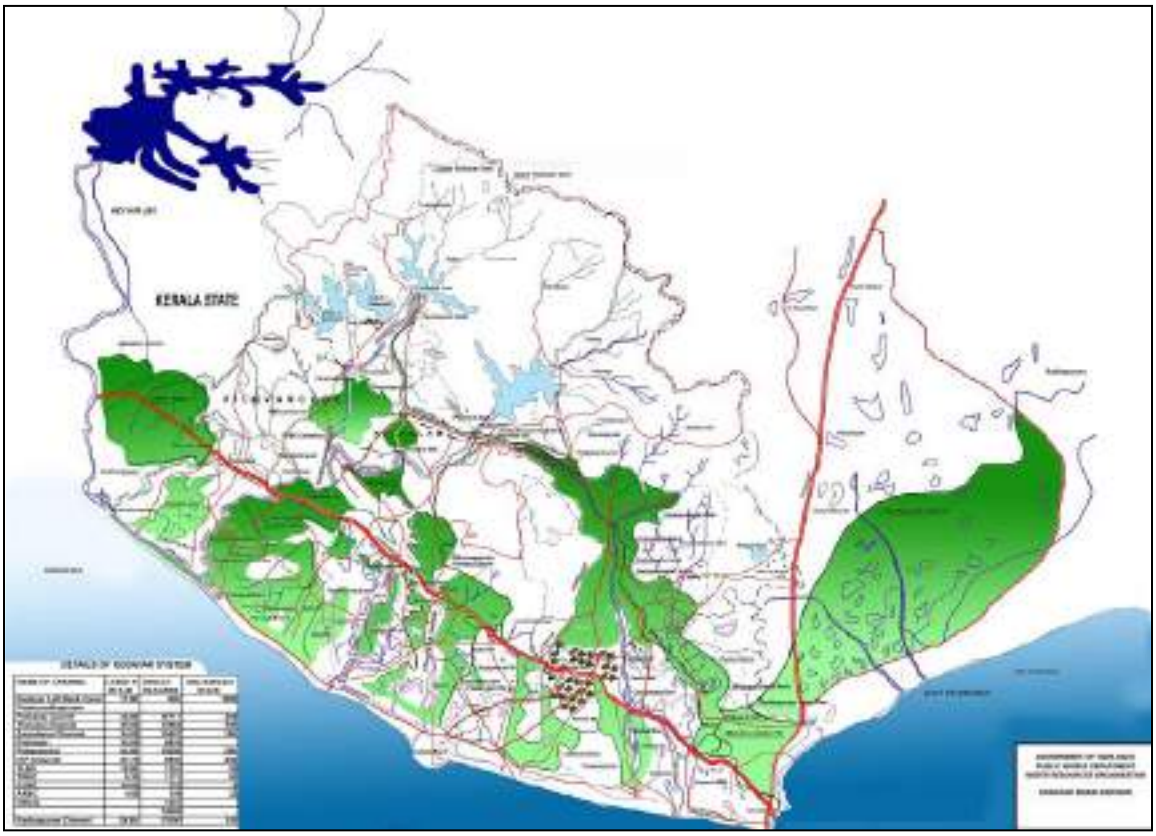


Figure 35: Kodayar Basin Command Map

The Padmanabhapuram Puthanar irrigates vast tracks land in Kalkulam Taluk. Thovalai channel extends upto Tirunelveli District by the name of Radhapuram channel. The Regulator Kal after running for about 1.6 Km bifurcate into two at Surulacode, one on the right called the Anandanar Channel and other on the left Pazhayar. The pazhayar carries the entire drainage of the Valley. The main irrigation channel under Pazhayar is the Nanjil Nadu Puthanar taking off at the Chattuputhoor Anicut.

Besides then there are 10 other anicuts across thee course of the Pazhayar before it drains into the sea.The water of Chittar I and II are flown into the left bank canal of the Kodayar at the 5th Km and draw off at the 10.15 Km by the Pattanamkal channel. This channel irrigates vast areas lying between Tambraparni and Padmanabhapuram Channel in Kalkulam. Besides there is an anicut across the Paraliyar called Aruvikarai anicut irrigating about 266 Ha. of paddy land. There is a similar anicuts across Kodayar at Thirparappu irrigating about 258 Ha.

Sl.No.	Crop	Area(in Hect.)
1	2	3
1	Paddy	10988
2	Pulses	537
	Spices and condiments	
3	1. Areca nut	492
	2. Cardamom	48
	3. Chillies	4
	4. Ginger	10
	5. Pepper	101
	6. Nut meg	19
	7. Cloves and cinnamon	645
	8. Curry leaves	4
	9. Tamarind	1080
	10. Turmeric	0
4	Sugar Crops	1387
5	Fruits and vegetables	12734
6	Fibre Crops	0
	Food oil crops	
7	b) Ground nut	5
	c) Coconut	24916
	Non food oil crops	
8	a) Neem	9
	b) Illuppai	0
	c) Punnai	157
	Medicinal crops	
9	a) Coffee	81
	b) Tea	333
	c) Betel vine	43
	d) Cocoa	58
	e) Thulasi	0
	f) Sandal	0
	g) Musili	1
	h) Manjam	0
10	Manure crops	2360
11	Flowers	219
12	Grove varieties	318
	Other varieties	
13	a) Rubber	24094
	b) Mulberry	8
	c) Elavam/ Ulagu	10
	d) Gall	1
TOTAL		87686

Source	Number	Area Irrigated	
		Net	Gross
1	2	3	4
I. Surface Water:			
1. Canals			
i. Government Canals	53	10841.670	13736.140
ii. Private Canals	-	-	-
2. Tanks			
i. Large	2623	17064.750	22425.120
ii. Small	-	-	-
II. Ground Water			
i. Public	-	-	-
ii. Private Tube wells	**1304**	**168.350**	**211.440**
iii. Dug wells	**2056**	**432.200**	**460.870**
others	-	**155.410**	**155.460**

Table 11: Land Irrigation by crops and water-source

Agriculture sector in the district is passing through a difficult time. In the mean time, crop shifting poses another dimension to the existing problem. Though rubber is extensively cultivated in the district, paddy, coconut banana and tapioca are other major crops of the district. Since rubber is an important raw material for a number of industries, the growth of rubber plantation boosts the industrial sector. In a globalized era, there is a high potential for developing of rubber–based industries. In the prevailing market situation, international rubber price takes over the domestic price, which is conducive to export. The ever increasing demand for natural rubber paves way for crop shifting in the district.

3.4.4.2.2 Fishing

Kanyakumari District is having the coastal length of 68 kilometers covering 8 kilometers from Arokya Puram to Kanyakumari in the East coast and 60 kilometers from kovalam to Neerodi in the west coast. The District is comprising of 44 marine fishermen village with the population of 1.5 lakhs. Among this population 45000 Fishermen are engaged in Fishing profession. There are 41 Fishermen Co-operative societies, a fisherwomen Co-operative societies and 10 Inland fishermen Co-operative societies functioning in this District. Kanyakumari District consist of 45 landing centres. The catches are being marketed locally and through merchants.

At Chinamuttam a fishing harbour is functioning with landing and berthing facilities for merchandize boats and country crafts. In Kanyakumari District there are 935 catamarans, 86 Vallams and 156 Mechanized boats-registered in east coasts and 5462 catamarans 2509 vallam and 1172 mechanize boats registered in west coast. In this District two major fishing seasons are prevailing for east and west coasts separately. The season is as follows:

• East coast from June to September
• West Coast from June to October

Major fishers landed in the district are prawns, cuttle fishes, squid,white bait, Robbon fish, seer fish and Rocle perches in the east coast (Chinnamuttam) and west coast (Colachel). Fish have formed an important item of human diet from the time man appeared on earth and are primarily caught for the purpose. Fish diet provides proteins, fact and vitamins A&D. A large amount of phosphorous and other elements are also preset in it. They have a good taste and are easily digestible. A very large number of fresh water and marine fish are therefore regularly caught by hundreds and thousands of fishermen, all over the world and consumed as food.

Several million tonner of fish are cap turned every year by various methods such as spears, baited hobbies, traps and net. Fish are eaten in various ways either cooked or even raw, but they deteriorate rapidly after being caught and must be consumed soon or preserved for later use large scale industries have therefore developed in various countries for catching, preserving and exporting the fish to different parts of the world.

3.4.4.2.3 Industry

The economy of this District is also agriculture based. However, endowed with a lovely coast line, rich mineral resources like ilmenite, rutile, etc., a second line of economy is seen.

As is extended of an area with a sea coast, marine fishing has also its own contribution to make towards the district's economy. Another popular and enterprising industry is the turning out of fibre from coconut husks. The rubber plantation which covers an extensive area at present, came up only during the beginning of this century.

Handloom industry flourished especially at Vadesery, Kottar and Palliyady even though raw cotton is not locally available. Perhaps the conducive climate for handloom industry and the talent of a section of the people combined, contribute to the flourishing of the industry.

A. Large/medium scale units : 06
B. Small Scale Units (regd.)
No. of Units : 13,149

- Investment in P & M : 19,879 lakhs
- Employment : 19,738

Industrial Clusters	No. of units	Concentration (Blocks)
Cashew nut processing	200	All Blocks
Common Salt	10	Agastheeswaram
Coir products	250	Nagercoil, Agastheeswaram, Vilavancode
Rubber based industries	50	Nagercoil,Thuckallay

Table 12:: Kanyakumary main industries

- Rubber industries

India is emerging as a major manufacturer of rubber-based products. All the big automobile industries are having their manufacturing units in India. Thus the demand for NR is well seared and is continuously increasing at a rate of three to four percent per year which is in line with the improved living standards. Rubber in the form of sheet or latex concentrate is the raw material for producing more than 50000 different articles. The number is still increasing steadily since new applications are being discovered from it. So there is much scope for rubber plantations in the years to come.

Kanyakumari district counts with geographical features more suitable for rubber cultivation. It has the required soil, climate and topographic factors suitable for the cultivation of rubber trees. It is a fact that standard quality of rubber is available in Vilavancode and Kalkulam taluks of the district. Natural rubber is an important raw material for a number of industries.

Although the district accounts for nearly 98 percentage of latex production in the State of Tamil Nadu, there is nonproliferation of industries manufacturing rubber products. It seems to be against the principle of localization of industries. In the selected area of study, the rubber growers are encountering problems on cultivation, finance and marketing. Problems such as labour shortage, climate changes and diseases are rubber cultivation problems.

Whereas, more formalities, fluctuations in rate of interest, inadequate finance and frequency of repayment are identified as the financial problems. It has been identified that price fluctuation, visual grading and lack of storage facility are the major marketing problems.

When identifying and overcoming the factors impeding the growth of rubber based industries in the district which has the potential for abundant supply of raw latex., size of holdings influences the production and productivity of natural rubber. In the sample area size of holdings is becoming smaller year by year due to partition, disposal and conversion of agricultural land into residential, business and institution centres.

The following table shows the holding size of the sample respondents.

Holding size (in cents)	**Number of Respondents**	**Percentage**
Below 50	60	20
50 – 100	157	52
100 – 200	65	22
Above 200	18	6
Total	**300**	**100**

Table 13:: Kanyakumary Rubber cultivation. Holding size

It is clear from the above table that 52 percentage of the respondents are having less than one acre (100 cents) holdings. Only a meager two percentage of the sample have a sizable area of two to nine acres of land for rubber cultivation.

In Kanyakumari district, only 35 RPS (Rubber Producers Societies) are functioning and nearly 25 RPS have been forced to close down due to rigid formalities. Some relaxation is needed to reap the fruits of organizational structure in rubber plantation which is dominated by small holdings.

These weaknesses can be either removed or reduced to some extent by active participation of Rubber Board officials through the networking of Rubber Producers Societies and with the willing co-operation of the growers

However infrastructure development is the positive factor for the development of rubber plantation in the district. The measures for infrastructure development relating to rubber plantations are irrigation, road, railways, ports, airports and electricity. Irrigation is the artificial application of water to soil for the purpose of crop production. The district is irrigated by dams, canals, tanks and wells. Power is indispensable to make any industrial sector powerful. The setting up of new industries would provide faster economic growth in Kanyakumari district.

The already underdeveloped industrial sector in the district would get a boost by setting up new rubber based industrial units. It would remove the regional imbalance in industrial development to some extent. More industries could provide more revenue to the district. By developing the rubber based industrial sector, remunerative and secured market for NR could be assured. Export oriented industries would provide foreign exchange earnings to the country. By import substitution, drainage of foreign exchange could be prevented. The progress of rubber-based industries would ultimately lead to extensive rubber cultivation and increase in productivity of NR.

- Cashewnut industry

Cashewnut processing is predominantly an export oriented seasonal industry. The industry came into prominence only during the fifties and the number of cashewnut factories has since then been on the increase. The National Nut Company at Palugal, the Vijayalakshmi Cashewnut Industries and the Raju Vilas Roasting Plant both located at Palavilai are the main units in the district, while the rest are only small units, Put together, thereare196cashewunits. Women are mainly employed in shelling the roasted nuts and peeling the machine dried kernels.

- Handicrafts

Indian handicrafts known for its proud tradition are appreciated for their aesthetic and as well as their utilitarian values as a result they prove to be the most valued export commodities^ in our country and as well as abroad. The main crafts in the district are wood carving, stone carving, metal works, lace and embroidery, temple jewellery, kora grass mat, laminated wood, musical instruments and fibre craft.

Fibre craft is one of the popular handicrafts of the District. Availability of raw material (i.e.) banana sheath in plenty and deft hands to turn out lovely articles go hand in hand to create a ready market everywhere in the State especially at the tourist centre of Kanniyakumari. Because of its corisiderable potential to generate employment among women, the Centre and the State Governments have come up with schemes to popularise this craft, which are wide, ranging such as bags, tea coasters, table mats, door mats, fancy dolls, flower pots and flower pot hangers. Even the fibre dusts do not go a waste but they are dyed and used for painting.

Kanniyakumari district accounts for the largest manufacture of fibre articles in the country. Puviyur. Nagercoil, Tiruvarambu, Chungankadai, Manalikarai. Aramboly, Kollel. Pacodu. Idaikodu. Arumanai and Kattathurai are some of the important centres. The Fine Fibre Workers Cooperative Cottage Industrial Society which has membership of 300 women has been set up with the assistance of the Tamil Nadu Khadi and Village Industries Board. The members are imparted intensive training for three months in fibre craft.

- Wood Carving

This is very popular in the district which is evident from the fact that even today one can see the workmanship in the temple doors and the furniture in the Padmanabhapuram palace and the like. However, lack of encouragement and the increase in the cost of manufacture have led to the wane of this traditional craft and hence the industry is ebbing now.

The Tamil Nadu Handicrafts Development Corporation Limited in order to encourage and promote the industries, have set up a Poompuhar Temple Car Training Centre at Nagercoil to impart training in wood crafts such as in wood carvings, building temple cars and carved wooden doors. To market the finished products, a showroom with Sales centre in Kanniykumari has been set up by the Poompuhar. This product commands good demand at Kanniyakumari.

- Stone Carving

This is a traditional craft which flourished under the Pandyian kings known for their lavishness in constructing temples with rich intricately designed carvings on the stones used as pillars, ceilings, etc. In the temple at Suchindrum which excels in such exquisite carvings is a standing monument of beauty at which, one marvel, when he visits this temple. This traditional art has found its way into the 20th century also; for example the Vivekananda Rock Memorial was constructed meticulously with blue and red granite. The red granite used for the shikharams of the mandapam is very unique and imposing which has won the appreciation of one and all the world over. These two constructions thus reveal the traditional standards and the perfection in architecture or to say it is a harmonious blend of traditional art and architecture and thus the splendour which evokes interest to any visitor to these places. These arts still have roots in Mylaudy, Thirupathisaram and Aralvoimozhi.

- Bell Metal Industry

It is popular especially in the manufacture of brass vessels, lamps (kuthuvilakku) and temple bells. The brass vessels are largely ornamental with the images of Gods, flowers and sacred animals etched or carved on them. Kottar in Nagercoil has also long been associated with the manufacture of domestic vessels made of vellode or bell metal. The decline in market for this finished products has caused a set back to this industry. So, Poompuhar takes care of marketing these articles and as a result the industry now heaves a sigh of relief.

- Temple and costume Jewellery

This is similar to costume jewellery excepting that real gold leaf beaten to extreme thinness is used for covering the surface of the ornament. So, the ornaments made in this style are costlier. The ornaments made in the temple jewellery style are made to specifications to suit the temple deities. Costume jewellery: These are also similar to the temple jewellery except that the metal used is neither gold nor silver and hence cheap. These are used by the stage artistes. The craft is practised by a section of goldsmith belonging to the Viswakarma community at Nagercoil and Vadaseri.

- Kora Grass Mat

This is one of the most popular crafts of this district. This is a cottage industry which employs a large number of womenfolk and children. The korai grass is not available locally but procured from Karur in Tiruchirappalli district and Vellore in North Arcot district. However, the korai grass available in Vellore is not equal in quality as that of in Karur. The popular korai grass varieties used here are koolamattam and marmattam. Mat weaving centres are at Thuckalay, MadhavaJayam, Soorangudi, Thittumilai, Ethampoly, Irnepuram, Killiyoor, Athicode, Thiruvancode, Kanniyakumari and Kottar.

Reed and Bamboo Article: The area situated right below the Western Ghats has a reserve of lush forest where reed and bamboo are found grown in abundance side by side with rubber, cardamom and other growings on the hill. Like mat weaving, JhisJ^pufely a home craft where all the members of the household are involved. This craft is practised by tribal people mostly inhabiting in places below the mountain slopes. Though a wide range of articles are being made in this district, the most popular variety is the conical baskets which is commercially used for packing fruits, flowers, betel leaves, etc. for transportation to other places. Modern units located at

Kanniyakumari are now manufacturing dinner mats and wall hangings, etc. Reeds are used for weaving mats. Impressive paintings are produced in the mats.

- Palm Leaf and Screwplne articles

This is also one of the (In this district Mostly, adivasis and backward communrtm Irving along the slopes of western ghats have taken up to this avocation suchbaskets and mat weaving out of palm leaf and screwpine vrfiteh we used In packing betel leaves, fruits, flowers, etc, for transportation, fhej»e baskets are in big demand locally. Fancy bags are manufactured. These industries are amply found in Edaicode, Thlruvlthancode, Palugal, Azhagiamandapam Mettukadai and Thuctaiay

3.4.4.3. Roads and transport network

The network of roadways of a country is as essential as the arterial system to the human body. The roads in a big way facilitate advancement in the economy of a country and they simultaneously facilitate communication. In the matter of surface transport, they are almost equal to the railways which connect other parts of the country through its large railway network system. These two transports are not parallel but inter-dependent.

The Chennai-Kanyakumari Highway joins the Kanyakumari- Trivandrum road near Aralvoimozhi which passes through Nagercoil touching other important places and terminates at Trivandrum in Kerala State covering a distance of 62.4 km. from Aralvoimozhi to Kerala border. The views on either side of this road can never fail to attract the travelers.

Tracing the history of a regular system of road communication in the Kanyakumari area it dates back to 1860 and the credit goes to Sir Madhava Rao, the then Dewan of Travancore-Cochin State. The work part of it was executed by the Engineering Department which was set up during his period. However, these roads were primarily intended for the movement of troops, but in the days to come it accommodated civilian traffic also. During the rule of Rama Varma (1758-98 A.D.) a good road was laid between Kanyakumari-Kodungalaur (Crangalur).

Roads play a vital part in economic development, opening up remote areas, stimulating the growth of agriculture as well as industry, besides facilitating communication. As an essential element of the transport infrastructure, they contribute, along with the railways, the nation's lifeline.

The road network in Kanyakumari district consists of National highways, State highways, District roads and rural roads. The trunk road from Madras to Nagercoil joins the Kanyakumari – Trivandrum road near Aralvoimozhi and passes through important places over a distance of 62.4 Km. and finally enters Kerala State. The road from Kanyakumari to Trivandrum is one of the busiest roads in the country.

The erstwhile State of Travancore-Cochin adopted a policy of nationalization of transport and as a result the Transport Department was formed in the state in 1938. Routes between Trivandrum and Kanyakumari (Via) Nagercoil and Colachel were the first to be taken up for nationalization.

After the reorganization of States in 1956, the bus transport service in Kanyakumari district was taken over by the State Transport Department of the then Madras State. The important private bus operators in the district during 1960's were Messrs. Pioneer Motors (P) Limited, P.T.S. Motor Service and Sri Ganapathy Motor Service at Nagercoil and Messrs. R.K.V. Motors and Timbers (P) Limited and P.C. Motor Service at Marthandam.

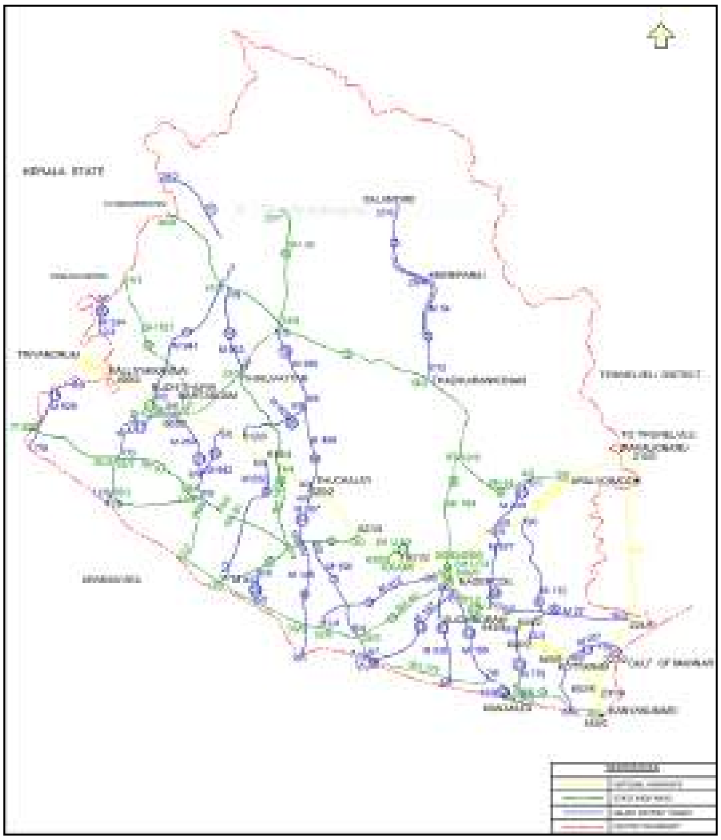


Figure 36: Kanyakumary District highways

3.4.4.4. Infrastructures

- Electricity

Tamil Nadu Electricity Board has remained the energy provider and distributor all these years. Tamil Nadu Electricity Board was restructured as per G.O.114 dated 08.10.2008 by establishing a holding company with the name "TNEB Ltd" and two subsidiary companies namely "Tamil Nadu Transmission Corporation Ltd.,"(TANTRANSCO) and "Tamil Nadu Generation and Distribution Corporation Ltd.," (TANGEDCO) as per the mandatory requirements of the Electricity Act 2003. Accordingly TNEB Ltd., was formed on 01.11.2010.

Sl.No.	Name of the Power Stations	Year of Operation	Installed Capacity (M.W.)	Generation (M.U.)	Station Consumption (M.U.)	Nett Unit sent out (M.U.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.	HydroKodayar Power House-I	36th year	60	152.378	0.283146	152.094854
2.	Kodayar Power House-II	35th year	40	90.23361	0.224431	90.009179

Table 14:: Kanyakumary Power Stations Source: *Tamil Nadu Electricity Board, Kodayar.*

There are three Operation and Maintenance (O & M) Divisions in the District, each headed by an Executive Engineer with headquarters at Nagercoil, Thuckalay and Kuzhithurai. These Executive Engineers are responsible for the proper maintenance of power supply to the consumers in their respective areas. One construction-cum-commercial division headed by an Executive Engineer is also functioning, which looks after the construction works for extension of supply to new consumers in the district.

Sl.No.	Sectors	Consumption (M.U)	% of the Consumption
(1)	(2)	(3)	(4)
1	Industries	25.860	8.41
2	Agriculture & Huts	31.800	2.64
3	Domestic	250.001	38.06
4	Commercial & Ty.Sy	86.000	38.106
5	Public lighting and Public Works	28.490	9.57
6	Sales to licensees	-	-
7	Sales to other States	-	-
8	Miscellaneous – HT	40.185	3.214
	Total	**462.342**	**100**

Table 15:: Power consomption sectorwise Source: *Kanyakumari Electricity Distribution circle,*

- Water supply and sanitation

Combined Water Supply Schemes (CWSS) are being implemented where more than one local body either urban or rural with a common source of water supply is involved with financial assistance under the Minimum Needs Program , National Rural Drinking Water Program and with funding from financial institutions like TUFIDCO, TNUIFSL, NABARD and Asian Development Bank.

At present, water being supplied to the beneficiaries of Town Panchayats and Village Panchayat of this CWSS through Bore wells, open wells and infiltration wells in River Pazhayar. The sources are mainly recharged by irrigation channels during the flow period of nine months only. This is not sufficient throughout the year. Keeping in view the severity of the problem for providing adequate safe drinking water perennial river Kothayar River is proposed as source. It is proposed to draw the total net requirement of raw water from Kothayar River on the upstream side of Thirparappu falls at Kaliyal.

It is proposed to tap the Raw water from River Kuzhithuraiyar near Chengilagam through 8 m dia meter intake well. The water from the intake well will be pumped to the proposed 1 lakh litre Sump by 3 set of submersible pumpset through 250 mm CI LA class pipes. The water from the sump will be pumped to the Treatment site at Athencode by 3 sets of Centrifugal pumpset through 600 mm BWSC Pipe. After the full scale treatment the water will be pumped to the various beneficiaries through existing system of pumping mains of 22420 m by interlinking. It is also proposed to replace the existing pipe line for a length of 5415 m, for the 79 habitations in Melpuram Union,and it is proposed to lay 80383 m of pumping main and branch pumping main.

The raw water will be abstracted through off take well from the river and will be pumped for about 23.28 KM through 700m MS and 500 mm and 450mm DI Pipes to the proposed treatment unit of Capacity 19.15 MLD at Arumanallur. From the Treatment Unit, the clear water will be conveyed to the proposed 39 Nos of sumps in the Town Panchayats and Village Panchayats through 500mm to 200 mm DI Pipes and 160 mm to 50 mm PVC Pipes for a distance about 162.16 KM.

From the sumps water will be pumped to the existing 287 numbers of existing service reservoirs and 4 nos of proposed service reservoirs in the Town Panchayats and Village Panchayats for a length of 271 KM and water will be distributed to the existing distribution system. The project area extends in Kanyakumari District covering 3 unions and 9 Town panchayats and 246 rural habitations in 30 village panchayats as detailed below.

Sl. No.	Description	Population			Water Requirement MLD	
		2014	2029	2044	2029	2044
1	Town Pts. – 9Nos.	119870	144400	159610	12.36	13.86
2	Rural panchayats- 30 VPs (246 habs.)	113989	115399	136793	4.29	4.58
	Total	233859	269799	296403	16.58	18.44
		Raw water Requirement			19.15	21.30

Table 16:: CSSW Project Scheme in Knayakumary District. Population and Requirements.

- Health

Government Kanyakumari Medical College has been functioning since 20-03-2007 at Asaripallam. Government Ayurveda Medical College is also functioning in Kottar by the State Government. At Kanyakumari district health care delivery system to the rural has been provided by 9 Block Primary Health Centers, 27 additional Primary Health Centers, 6 Urban Primary Health Center and 267 Health Sub Centers. Through these health centers curative and preventive services are being extended to the rural community.

However , the Siddhars (practitioners of herbal medicines) system of treatment (has been preserved carefully by the people of Kanyakumari. The District has contributed much in the field of Medicine. The district is endowed by nature with several hills and mountains with rich herbs of medicinal value and minerals.The growth of allopathic system of medicine in Kanyakumari district is also an interesting one. The early Protestant Christian Missionaries were considered pioneer in the field of allopathic medicine of the district . By establishing a hospital at Nagercoil, the London Mission Society (LMS) known as Church of South India (CSI) has laid the foundation for the modern allopathic system of practice in the district as early as 1838. The district owes much of its present position and importance, to the efforts of the Missionaries in the field of medicine.The allopathic system, introduced by the British was adopted as a State system of relief in due course.

Another native system i.e.,Chintamani, which formed part of ayurvedic science was also prevalent in the district. This system describes the means of ascertaining diseases by the examination of the pulse. Since this system needed more care in the preparation of the mineral drugs, the number of patients was very limited.

Sl. No.	Name of the Hospital	No. of Doctors	Sanctioned Bed
1.	Head Quarters Hospital, Padmanabhapuram	21	108
2.	Kanyakumari	5	51
3.	Kuzhithurai	10	86
4.	Bhoothapandi	7	41
NON-TALUK HOSPITALS			
5.	Colachel	7	38
6.	Kulasekaram	5	36
7.	Arumanai	3	21
8.	Senam Vilai	3	-
9.	Karungal	3	12

Table 17:. Kanyakumary Public health and medical services

- Education
  - Primary and Secondary Education

The District Provides free and quality education to children. The district core planning team functions under the chairmanship of the District Collector. The team comprises District Programme Co-ordinator, Chief Educational Officer, DEO (Secondary), DEEO, Asst. Programme Officer, Statistical Officer, Principal, DIET, Representatives from Health, Public & Social Welfare Dept and DRDA. It is well recogonized that eight years of education are insufficient to equip a child for the world of work as also to be component adult and citizen.

Sarva Shiksha Abhiyan (SSA) or "Anaivarukkum Kalvi Thittam" is a flagship programme for achievement of Universalization of Elementary Education (UEE) in a time bound manner, as mandated by 86th amendment to the Constitution of India making free and compulsory Education to the Children of 6-14 years age group, a fundamental Right. Sarva Shiksha Abhiyan is an attempt to improve capabilities of all children through provision of community owned quality education in a mission mode.

Rashtriya Madhyamik Shiksha Abhiyan (RMSA) is a centrally sponsored scheme to achieve the universalization of Secondary Education. Its visions is to make Secondary Education of good quality accessible and affordable to all school age children in the age group of 14-18 years.

  - Higher Education

Colleges of higher education are found throughout the district, mainly art, science and engineering colleges. The *Scott Christian College*, founded by *William Tobias Ringeltaube* in Nagercoil, is more than 100 years old. The state runs the *Kanyakumari Government Medical College* at Asaripallam, a Government Engineering College and a Government Polytechnic at Konam, near Nagercoil. Many private Engineering Colleges including a private university were started-functioning in the recent past.

No fewer than 30 engineering colleges are functioning in the district which are currently affiliated to the Anna University; arts and science colleges are affiliated to Manonmaniam Sundaranar University, Tirunelveli. The Manonmaniam Sundaranar University runs a research unit — Centre for Marine Sciences and Technology — at Rajakamangalam, Kanyakumari District. Noorul Islam University is the only private university functioning at Thuckalay
Education changed the cultural,economic,social,scenario of the district and dramatically differentiate it from other districts. Kanyakumari district people occupy top level state & central Government postings and earned good reputations among colleagues.

3.5. SOCIECONOMIC PROFILE OF THE STUDY AREA. COLACHEL-ENAYAM

3.5.1. Colachel Municipality

Colachel is a Municipality of Kallkkulam taluk, which is is a *taluk* of *Kanyakumari district* of the *Indian state* of *Tamil Nadu*. The headquarters of the taluk is the town of *Kallkkulam*.Up to 1957, Kallkkulam Taluk formed part of the Travancore Kingdom and subsequently the Travancore-Cochin State. It was when the States were divided on linguistic basis that*Kallkkulam*, *Thovalai*, *Vilavancode*, and *Agastheeswaram* Taluks of the erstwhile *Thiruvananthapuram District* of the then *Travancore-Cochin* State were included in the then *Madras State* (later renamed as *Tamil Nadu*) as *Kanyakumari* District.

Figure 37: Colachel-Enayam. Harbour Project Area

Colachel Municipality consists of five functional departments. Each department consists of Head who reports to the Municipal Commissioner and functions as per the responsibilities prescribed in the Act and as delegated by the Commissioner.

The Commissioner is at the apex of this structure and is responsible for all activities carried out by the ULB. The Commissioner is responsible for preparation and certification of all periodical records, returns and furnishes all information as may from time to time be required by the Municipal Council or the Standing committees. He is also responsible for preparation of accounts. At each general meeting, the Commissioner along with some other key officials, discuss various issues with the elected representatives. The functions of various officials/departments, under the Administrative wing, are elucidated hereunder:

- General Administration Department: The department is headed by the Commissioner and assisted by Manager, Head Clerk, Public relation officer, Superintendent and other officers. This department is responsible for establishment, other essential matters relating to office, officers, staff and their welfare like preparation of staff pay bills, maintenance of registers for advances, GPF, pension, PF's etc.
- Engineering Department: The Municipal Engineer heads the engineering department, and is assisted by Assistant Engineer, Junior Engineer and other staff. With regards to fieldwork, Scheme works are delegated to one Junior Engineer who also looks after regular works, related to Public Works, Drains,

Street Lighting. The Assistant Engineer looks after the water supply and is assisted by electrician, operators and other staff. The Department is responsible for ensuring the quality and quantity of water supply to the municipality. A major function of the Municipality is formulation and execution of Works- like construction and maintenance of roads, buildings and other infrastructure systems.

- Revenue and Accounts Department: The department is headed by Revenue Inspector and assisted by junior assistant. The Accounts Section is responsible for supervising all financial transactions related to the ULB, advising the Revenue Officers on all internal financial matters, updating financial receipts and expenditure details in accordance with the utilization of funds, reporting deviations in expenditure of funds in any of the allocated schemes, assisting preparation of the ULB budget, maintenance of accounts regarding stamp duty, SFC Grants, MP Grants, maintenance of petty cash book and general cash book and attending to audit requirements and other such accounts-related duties. Revenue Officer, heading the Revenue Section, is responsible for collecting taxes such as, trade tax, house tax, advertisement tax, and entertainment tax; development charges; transfer of properties collection of duty; issuing notices for recovery of tax; and monitoring revenue collections of the ULB.
- Public Health Department: The department is headed by Sanitary Officer, and is responsible for ULB services such as Solid waste management, public health related works like malaria control, family planning, mother and child health care, birth and death registration etc, and other government assisted programs related to health and poverty reduction and awareness programs. The Sanitary Officer assisted by the Sanitary Inspectors and Sanitary Supervisors, is responsible for services of Solid waste management and Malaria Control activities. Sanitary Supervisors are in-charge of works execution at the field level, which includes monitoring and supervising the work of sanitary workers in the wards under their charge and attending to specific local complaints. Besides, this department is responsible for the enforcement of the Public Health Act.

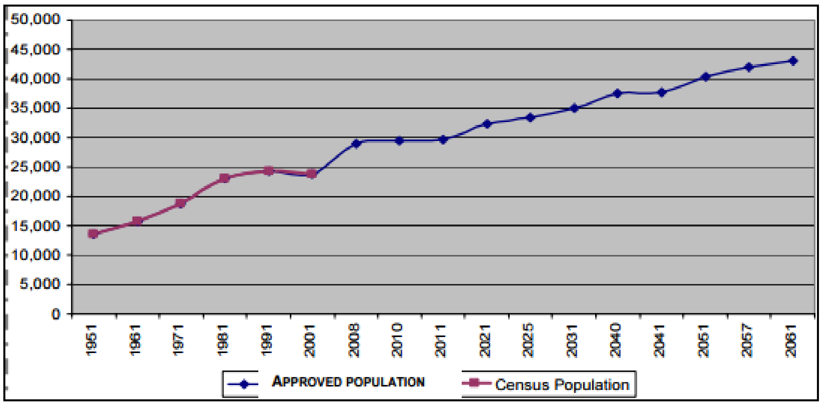
  The Public Health Department is vested with the responsibility of ensuring safe sanitation and cleanliness of the town. The department is also responsible for the maintenance of Municipal Dispensaries, Burial Grounds and slaughterhouses. One of the most crucial services of the municipality is maintenance of sanitation and cleanliness in the town. This involves mainly conservancy works involving sweeping of roads, garbage collection and disposal, cleaning of drains, and disinfecting of drains.
- Town Planning Department: A town-planning inspector heads this department, assisted by building inspectors, surveyors and junior assistants and other staff. The major function of this department is issue of building license, preparation and implementation of development plans and eviction of encroachments, urban planning and building regulation. The Town Planning Department's main function is to implement the master plan proposals, ensure orderly growth in the town and avoid unauthorized constructions and to formulate projects.

3.5.2. Demography an Social stratification

According to the 2011 census, the Taluk of Kallkkulam had a population of 603,918 with 303,913 males and 300,005 females. There were 987 women for every 1000 men. The Taluk had a literacy rate of 84.77. Child population in the age group below 6 was 24,542 Males and 23,696 Females.

Colachel population of the town was 23,787 persons. The ward wise population details of the town is given in the following table. The town consists of 24 wards. Males constitute 51% of the population and females are about 49%. In Colachel, 11% of town's population is under 6 years of age.

From the population projection performed is observed that 'Arithmetic Increase Method' is the optimal projections for the purposes of planning for urban infrastructure projects in both cases. Thus, it is recommended to select the projected value of 'Arithmetic Increase Method considering 1991 census as the design population for the respective project design stages and vision period. The recommended projected population is given in the following table



Year / Stage	Census Population	Projected population based on 1991 population	Projected population based on 2001 population
1951	13,606		
1961	15,673		
1971	18,819		
1981	23,124		
1991	24,305		
2001	23,787		
2008		28,852	25,212
2010		**29,387**	25,620
2011		29,655	25,823
2021		32,329	27,859
2025		**33,399**	28,674
2031		35,004	29,896
2040		**37,411**	31,728
2041		37,679	31,932
2051		40,354	33,968
2057		41,958	35,190
2061		43,028	36,004

Table 18: Colachel approved population

Enayam is a small location in Vialavancode Taluk. According to the 2011 census, the taluk of Vilavancode had a population of 587,924 with 290,860 males and 297,064 females. There were 1021 women for every 1000 men. Vialavancode has a literacy rate of 82.43. Child population in the age group below 6 was 27,715 Males and 26,478 Females.

Enayam Puthenthurai is a Village in Killiyoor Taluk in Kanniyakumari District of Tamil Nadu State, India. It is located 32 KM towards west from District head quarters Nagercoil. 6 KM from Killiyoor. 741 KM from State capital Chennai. Enayam Puthenthurai is surrounded by Munchira Taluk towards North , Melpuram Taluk towards North , Parassala Taluk towards North , Thackalai Taluk towards East. This Place is in the border of the Kanniyakumari District and Thiruvananthapuram District. Thiruvananthapuram District Parassala is North towards this place . It is near to the Kerala State Border.

Kulitthurai Rail Way Station , Palliyadi Rail Way Station are the very nearby railway stations to Enayam Puthenthurai. How ever Trivandrum Cntl Rail Way Station is major railway station 43 KM near to Enayam Puthenthurai

3.5.3. Economic development

Colachel having been located on the coastal side, the foothills have loamy soil and with good vegetation cover. The existing geographical conditions of the town support fishing to a greater extent for marketing in the town. Fishing is the primary occupation of the people in the town. Paddy, Banana and Coconut are the major crops cultivated in this region. Banana is the chief crop cultivated in this region and so Colachel Municipality is the marketing centre for the whole sale and retail trade of the banana cultivated in the surrounding areas. The town is the nodal centre for the fishing related activities happening around the town.

According to the fishery department, there were 300 mechanized fishing boats available in Colachel town, the cost of each boat ranging from Rs. 3 lakhs up to Rs. 50 lakhs. The major catch is during the three month period between September and November. The recent tsunami hit the shores of Colachel on Dec 26, 2004 and caused heavy damages to lives and the properties.

The Tsunami disaster has resulted in loss of hundreds of innocent lives (515 lost their lives). The Government of Tamil Nadu also plans to construct a fishing harbor with the assistance of Tsunami Fund from the World Bank. Other than fishing, the town also has 4 numbers of small industries, 2 ice plants and 2 rice mills.

3.5.4. Occupation Pattern

As per 2001 census the total workers in the town is 7,458. Work-force constitutes 31% of the town's total Population. Of them male workers are 6,546 and female workers are 912. Of the total workforce in the town, the maximum percentage is in the tertiary sector activities, which constitutes 95.08% of total workers and the minimum is the Secondary sector, accounting for 1.58% of total workers.

Year	Total Population	Total Workers		Primary Sector		Secondary Sector		Tertiary Sector	
		No. of Workers	% of Workers	No. of Workers	% of Workers	No of Workers	% of Workers	No. of Workers	% of Workers
1991	24305	6175	25.41%	4200	68.02%	175	2.83%	1800	29.15%
2001	23787	7458	31.35%	118	1.58%	249	3.34%	7091	95.08%

Table 19::. Colachel occupation patterns

The primary sector is only 1.58%. As for as Colachel town is concerned, fishing and related trade is the major economic activity as per 2001 census, which has brought the fishing and related activity in the other workers category viz tertiary sector. Employment generating opportunities are lesser in this town, since the town does not have any major industrial establishments.

3.5.4.1. Tourism

As far as the tourist attraction is concerned, Colachel is located within the administrative jurisdiction of Kanyakumari District.

Colachel is a second grade Municipal town situated on the west coast of Kanyakumari District. It is an ancient port town, Vasco-Da-gama called it 'Colachi'. Before the State re-organization in1956, it was part of the Travancore State. It was a Dutch colony which came under Travancore. After the defeat of the Dutch by King Marthandavarma in 1751, a victory pillar had been erected near the beach in commemoration of the victory.

The Western Ghats ending into green hills perennial rivers, lotus filled tanks, dense forests with wild elephants, extensive paddy fields, rich palm grooves, wavy coconut gardens and a carved coastal line of nearly 70 km. length are the unique natural features of the Land's Endpromontory of India Traveling in such a small, old and beautiful district is not only a feast to the eyes but to the mind also.

3.5.4.2. Fishing

Historically, fishing has been a major source of livelihood for some coastal and inland fishing communities. The Fisheries sector in the area plays a crucial role in the overall economic development of the State. The rich fish biodiversity of the project area offers good scope for fisheries development. The Fisheries sector, which started only as a subsistence livelihood activity during the early plan period is now emerging as a vital sector, contributing to employment generation, food security and foreign exchange earnings significantly. The fishing grounds along this part of the southwest coast are quite extensive and very productive. The sea bottom is generally muddy and sandy.. The 50 m depth contour is at a distance of about 25 km from the coast in our sector. The width of the continental shelf from the shore varies from about 65 km off Kerala to about 25 Km in the south.

The annual average fish landings along the southwest coast was 630 000 t during 1970 - 97 (see Pillai et al. this vol.), or 37% of total Indian landings. The southwest coast ecosystem is characterized by the abundance of oil sardine, Indian mackerel and penaeid prawns, which together contribute 45% of the landings. In addition to these groups, whitebaits, lizardfishes, threadfin breams, carangids, flatfishes and stomatopods also contribute a high percentage to the landings.

A variety of craft and gear combinations are being used by the commercial fishing sector along the southwest coast. Among the mechanized vessels, trawlers are the most common, followed by gillnetters. Of the various traditional crafts, catamarans are prevalent only in the southern sector, while dugout canoes and plank-built boats are prevalent along the entire coast.

However during the last few years more and more traditional crafts are being fitted with outboard engines, the technological developments in craft and gear are becoming counterproductive. There is evidence that several fish stocks along the southwest coast are overexploited, and declining.

The Colachel-Enayam sector fishermen mostly depend on the pelagic fishes that live at the certain depth according to the ocean floor classification. A variety of craft and gear combinations are being used by the commercial fishing sector along the Colachel coast . Among the mechanized vessels, trawlers are the most common, followed by gillnetters. Of the various traditional crafts, catamarans are prevalent only in the southern sector, while dugout canoes and plank-built boats are prevalent along the entire coast.

However during the last few years more and more traditional crafts are being fitted with outboard engines.

Annual average fish catches along the southwest coast increased from 0.19 million t in 1950 to 0.80 million t in 1997 (Devaraj et al. 1997). The increase was largely due to research and development efforts by different organizations. Motorization of indigenous craft started in the early 1980s, and became instantly popular. Consequently, most of the indigenous craft have been fitted with outboard motor and fishing with non-motorized craft has become rare.

However, the technological developments in craft and gear are becoming counterproductive. There is evidence that several fish stocks along the southwest coast are overexploited, and declining (De-varaj et al. 1997). Hence, implementation of appropriate management measures is imperative.

- Traditional and modern fishing methods

In Colachel-Enayam seacoast sector , conflicts are rampant recently. It cannot be denied that technologies like mechanisation of fishing crafts and introduction of purse seining and bottom trawling are powerful but greatly destructive. These modern technologies scoop up whole shoals of fish right from young ones to gravid. Hence renewability of sea with new recruit has been lost and at the same time scooping unwanted organisms also has broken important links of this food chain of marine ecosystem.

Traditional fishermen used catamaran and eco-friendly nets, which capture fish of specific size. The have understood the breeding season of fishes (described as Thethu) There are four Thethus or seasons according to the availability of fish shoal, water current, wind direction and the colour of the seawater. According to these only, fishermen go to the sea. This has given the margin to fishes to breed and to grow. By this naturally new recruits and renewability in the marine environment is possible. This approach never depleted fish biomass in the marine environment. Because of this, time and again, traditional communities are insisting on the total banning of trawl net (bottom trawlers) and insist on the regulation of fishing during breeding season.

It cannot be denied that technologies like mechanisation of fishing crafts and introduction of purse seining and bottom trawling are powerful but greatly destructive.

Along the Kanyakumari coast, traditional and modern fishing mix, although there has been a notable increase in the number of motorised and mechanised boats. Thus, in the ports of Chinamuttom and Muttom, most boats are mechanised –200 in Chinamuttom. Colachel Port, which is currently being expanded, harbours around 25 mechanised boats.

Throughout the coast from Kanyakumari to Eramanthurai, around 34 fishing villages can be found. Most of them have no ports, so boats are beached. Such landing sites have been identified in the field study. The following illustration shows the fishing landing sites and harbours found along the coast line.

		
Chinamuttom fishing harbour, more than 200 vessels berthed	Muttom fishing harbour.	Colachel fishing harbour (2015), Catamarans and mechanized boats
		
Traditional catamarans at Annainagar	Motorized fishing boats at Enayam	Shipyard at Enayam

Figure 38:Traditional and modern fishing methods

Fishing sector

Although Kanyakumari's coastline is only a small part of the total area dedicated to fishing in Tamil Nadi, it is practised profusely along the whole coastline.

The current trend is based on the upgrading of boats, which now feature outboard engines and have greater capacity and size. The number of motorised boats has also grown.The state-managed Port of Chinamuttom, the privately-managed Port of Muttom, and the expansion and upgrade of the Port of Colachel, all point to greater activity, more employment, modernisation and more catches. Mechanised boats (over 200 in Chinamuttom and more than 25 in Colachel following the expansion) increase the number of catches and enable catching bigger fish such as tuna.. Traditional catamarans only allow for a single fishing trip per day, because they cannot move more than 20 nautical miles away from the coast, while mechanised boats can fish for 4 or 5 days in the Wadge bank and near Sri Lanka.

		
Catamarans at Colachel	Catamarans at Manavalakurichy	Catamarans at Manakudy
		
Colachel harbour fish market	Kanyakumari Fish market	More than 200 tuna fish caught during 4 days fishing. Colachel port
		
Shrimps. Colachel Harbour	Sardines and other cupleids. Muttom harbour	Blood snapper (Lutjanus sanguineus). Kanyakumari

Figure 39: Fishing sector infrastructures

The fishing sector is essential in coastal towns, as it is the main source of income. However, there is still a need for investment in land facilities to help preserve catches through a cold chain, warehouses, workshops and a fish market.

The following table shows the fish landing figures for Tamil Nadu in 2013.

Marine fish landing by species in Tamil Nadu. 2013	
Fish Specie	Fish landing (in tonnes)
Sardinella Indian Oil Sardine	50181
Leiognathus (Silver Bellies)	34285
Decapods (a) Penaeid Prawn	32309
Marine Crust Crab	29087
Lates Sp. Lutjanus (Perches)	27844
Other Clupeids	24962
Other Marine Fishes	23913
Chirocentrus spp.	18242
Elasmobranchs (Shark, Rays, Skates)	17830
Engraulidae (Anchovies)	17633
Upeneus spp. (Goat Fish)	15275
Caranax spp.. (Kala Bangada)	14654
Sciaenidae (Croackers)	13663
King Mackerel (Indo-Pacific)	12502
Seer Fish Scomberomorus spp.	11690
Cephalopods (a) Squid & Cuttle Fish	10616
(b) Non-Penaeid Prawn	8636
Trichiuridae (Hair Tails)	8571
Scombridae (Tuna Like Fishes)	7264
Sea Catfishes	4468
Exocoetus (Flying Fish)	4210
Sphyraena spp. (Barracudas)	3417
Mugilidae (Mullets)	2750
Hemirhamphus spp. (Half Beaks)	2621
Bregmaceros	2234
Stromatidae (Butter Fish)	2234
Polynemidae (Indian Salmon)	2019
Lizard Fishes	1202
Trachinotus spp..	1031
Crustacea (Marine crustaceans)	687
Lactarius (Parava)	202

Table 20:Marine Fish Landings. Tamil Nadu 2013

All the coastal fishing sites have been identified, from Chinamuttom harbour to **Thengapattanam** approximately 55 Km of coast, by field surveys and aerial photography.

Each fishing sites has been categorised based on its conditions to boat landing as follows:

Type of fish landing site	Category
Open fish landing site	1
Fish landing site protected by groyne(s)	2
Small fishing harbour	3
Fishing harbour for mechanized boats	4

Table 21 Marine Fish Landings Sites. Tamil Nadu 2013

The following table shows the results for the entire affected coast.

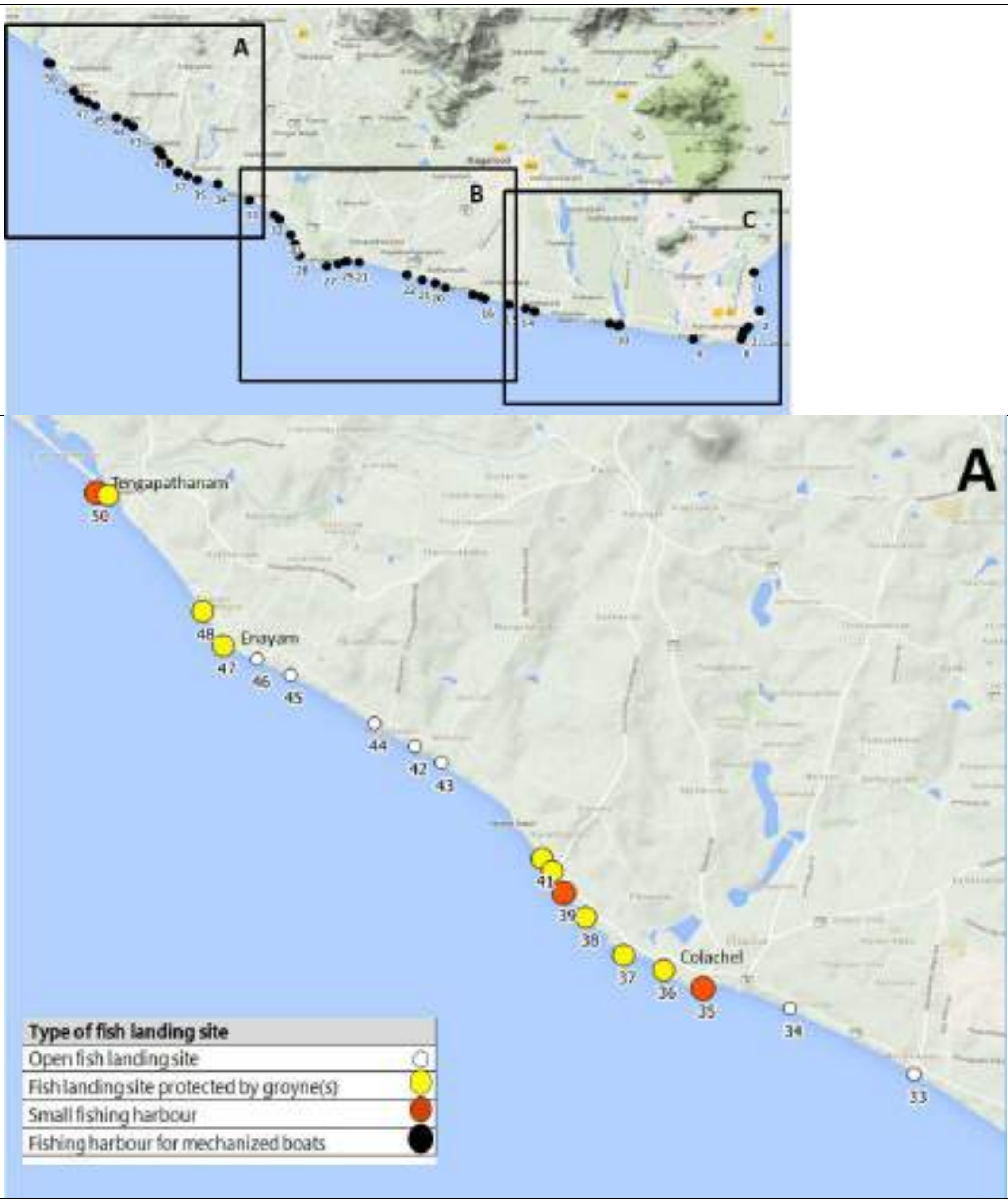
id	Location	Category	No. Of Catamarans and other boats	No. Of Mechanized vessels
1	Vattakkottai	3	63	4
2	Chinamuttom	4	89	265
3	Kanyakumari	2	8	0
4	Kanyakumari	2	26	0
5	Kanyakumari	3	49	1
6	Kanyakumari	3	56	0
7	Kanyakumari	3	17	0
8	Kanyakumari	3	27	3
9	Kovalam	2	93	0
10	Manakkudy	3	196	0
11	Manakkudy	2	4	0
12	Manakkudy	1	27	0
13	Annainager	1	16	0
14	Pallam	1	85	0
15	Puthenthurai	1	5	0
16	Kesavan	1	7	0
17	Kesavan	1	58	0
18	Pozhikarai	1	6	0
19	Periyakadu	2	53	0
20	Rajakamangalam Thurai	1	39	0
21	Rajakamangalam Thurai	1	58	0
22	Murungavilai	2	5	0
23	St'Antony's	1	25	0
24	Pillaithoppu	2	39	0
25	Muttom	3	37	0
26	Muttom	4	0	45
27	Muttom	3	220	0

id	Location	Category	No. Of Catamarans and other boats	No. Of Mechanized vessels
28	Kadiyapattanam	1	40	0
29	Kadiyapattanam	1	85	0
30	Chinnavilai	1	20	0
31	Chinnavilai	1	7	0
32	Chinnavilai	1	25	0
33	Mandaikadu	1	54	0
34	Kottilpadu	1	16	0
35	COLACHEL	3	243	25
36	COLACHEL	2	32	0
37	ST. Barthalomew	2	29	0
38	ST. Barthalomew	2	22	0
39	Kurumpanai	3	3	0
40	Kurumpanai	2	98	0
41	Kurumpanai	2	6	0
42	Miladam	1	5	0
43	Miladam	1	28	0
44	Melmidalam	1	32	0
45	Keezhkulam	1	41	0
46	Keezhkulam	1	5	0
47	ENAYAM	2	162	0
48	ENAYAM	2	292	0
49	Thengapattanam	2	56	0
50	Thengapattanam	3	262	0
		Total	2871	343

Table 22 Fish Landings Sites Category . Tamil Nadu

The total number of catamarans and small fishing boats is 2871, the total number of mechanized vessels 343. These numbers may be underestimated, since some of the vessels were out fishing when the counting was done in the workshops. A 5 to 10 % increase on these numbers should be estimated; which means around 3000 catamarans and other boats and about 370 mechanized vessels.

The following illustration shows the location of each identified point.


A
B
C
A
Tengapathanam
50
48
Enayam
47
46
45
44
42
43
41
39
38
37
36
Colachel
35
34
33
Type of fish landing site
Open fish landing site
Fish landing site protected by groyne(s)
Small fishing harbour
Fishing harbour for mechanized boats

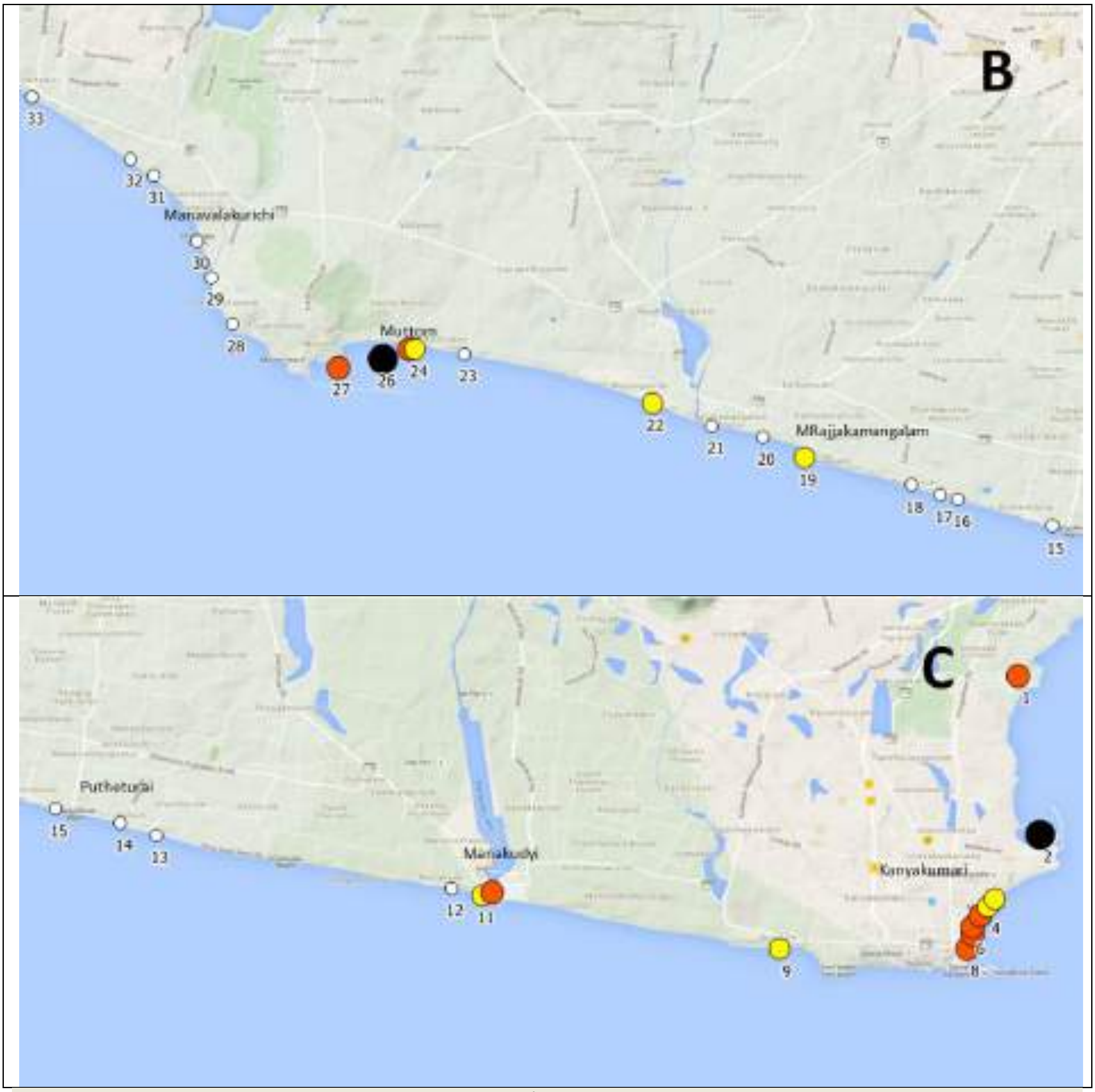


Figure 40: Fish landing sites and fishing harbours along the study coast

- Close fishing seasons

In India, the maritime state governments are responsible for formulation and implementation of fisheries management measures. At present, the maritime states in the southwest coast observe closed fishing season for the mechanized vessels for a period of 45 to 60 days during the southwest monsoon (June-September). Also, mechanized vessels are banned from fishing within 5 km from the shore. However, the effectiveness of these restrictive management measures on the sustainability of the resources has not been demonstrated.

These management measures, on the other hand, have resulted in inter and intra sectoral conflicts. Management measures, which are effective for sustainability of resources and are acceptable to all stakeholders need to be developed.

In Kanyakumari district mechanized vessel are banned from June 15th to July 31th, there are no closing fishing period for traditional catamarans.

Figure 41: Fishermen at Midalam

Figure 42: Kodimunai village

Despite of the enormous increase in the fisheries population the prosperity, welfare and development of the fisher folk in the area as measured by the government authorities are seemed to be a major obstacle or a matter of ever concern. The majority live under poverty and financial instability and therefore, they are at the lowest level of their profile in terms.

The rise in global temperature and unpredictable storms including tsunamis which could eventually affects the ocean ecosystems, fishing community, and consequently the raising ocean levels rising. These effects in turn has the impact on changing the Potential fishing zones which directly affects the fishermen communities by forcing them to face several challenges during their regular catch. It appears that there is scope for increasing the catch of large zoobenthic feeders, mesopelagic feeders such as the carangids, and plankton feeders such as sardines, shads, whitebaits, Thryssa spp. and other clupeids and scads.

Any new coastal activity of great socio-economic impact such as the new port should take this social and economic reality into account, provide support if possible and avoid conflict.

- Fishing harbour

Economy of the area is evolved based on the fishing and agricultural products like coconut, banana, etc. the employment generation from agriculture in this town is limited and agro based industries can be developed in this town. Establishment of fishing harbor either in Colachel and/or Enayam towns will ensure employment to people. Because of the area is affected by tsunami, extra care need to be taken to improve the economic base of this.

The fishing activity is not happening in an organized manner at present. Fishing harbour needs to be established with the facilities like Auction hall, Loading area, Parking area, Gear shed, Work shop, Net Mending Shed, Rest shed, Generator facility, Public toilets, Canteen, Over head tank, Administrative block, Radio communication centre and Fuel filling station.

3.5.5. Land Use

The has constituted a Local Planning Area (LPA) for Colachel, extending over an area of 2512.58 hectares under the Town and Country Planning Act, 1971 under section 11(3) by Government of Tamil Nadu in their G.O. Ms. No. 651 RD & LA Dept. dated 08.04.1975. This LPA area exclusively consists of Colachel Municipality alone. A First Master Plan for Colachel was prepared by the Directorate of Town and Country Planning (DTCP. Given the trends in development and spatial growth, a Master Plan for Colachel town, for 2010, was prepared by DTCP and submitted to for approval during the year 2005

3.5.5.1. Existing land-use pattern

The total area of the town is 5.18 sq.km. Faster pace of developments are happening in the 54% of the total land available for development as the remaining 46% of the land is under non-urban use, which is another important aspect of this town. The land under non-urban use includes agricultural lands both wet and dry, and Water bodies. This tends to indicate that the growth is restricted within the 54% of the available land, thus increasing the density in the already developed areas.

Land Use	Area in Ha.	% to Total
Residential Use	136.88.32	42.16
Commercial Use	5.95.66	1.83
Industrial Use	3.20.35	0.99
Educational Use	2.93.50	0.90
Public & Semi-Public Use	4.37.81	1.35
Transportation	21.23.34	6.54
Sub Total (Developed Area)	**174.58.98**	**53.78**
Agriculture (wet and dry)	132.41.83	40.79
Water bodies	17.63.72	5.43
Sub Total (Undeveloped Area)	150.05.55	46.22
Total	**324.64.53**	**100.00**

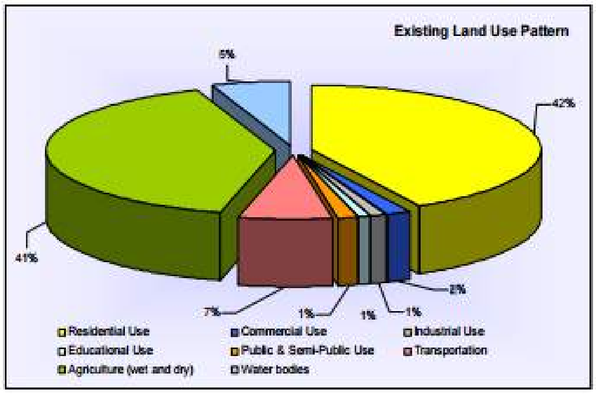


Table 23 Colachel existing land-use pattern

3.5.5.2. Proposed land use:

Due to physical and topographical feature of the land within the municipal limits such as Arabian Sea shore, water courses, channels, tanks and the low level wet lands, the possibility of proposing these lands for future urban development in the Master plan is less. However, in the Master plan, additional areas have been proposed in and around the existing built-up areas of the town to a certain extent taking into account the anticipated increase in population.

Land Use	Area in Ha.	% to Total
Residential Use	187.73.12	58.01
Commercial Use	3.41.19	1.05
Industrial Use	0.10.00	0.03
Educational Use	2.40.00	0.74
Public & Semi-Public Use	0.76.21	0.24
Transportation	13.28.00	4.10
Sub Total (Developed Area)	**207.68.52**	**64.17**
Agriculture (wet and dry)	30.30.41	9.36
Water bodies	*9.92.19*	3.07
C.R.Z	*75.72.80*	23.40
Sub Total (Undeveloped Area)	***115.95.4***	**35.83**
Total	**323.63.92**	**100.00**

Table 24 :. Proposed land-use pattern

- Residential use: Additional area proposed in the master plan is about 50 hectares (58%) and the additional population anticipated can be accommodated in the area.
- Commercial use: The town serves the shopping needs of the town and its hinterlands. Additional commercial areas have been proposed and marked in the land use map.
- Industrial use: Scope for industrial development in this town is limited due to the nonavailability of vacant land or Urban developable land within LPA. Unemployment problem of local people and outward migration of the people can be controlled to some extent by establishing additional industries utilizing the raw materials such as coconut fibers and fish.
- Preservation of protected areas: The proposed Master Plan envisaged the protection of double and triple crop wet lands from building activities and coastal stretches up to a distance of 500m from HTL to restrict building activities.

Development Potentials: Growth potential of the town is more pronounced at the regional level, for the town is the nodal centre for nearby towns and villages. The location of the town on the State highways makes it easily accessible and supports the town’s economic potential i.e. fishing trade. The well established connectivity of the town with surrounding areas also enables faster growth.

Constraints: The Development of the town is constrained by four main factors. They are:
• Location of the Arabian Sea in the southern fringe, the Pampoori vaikal channel running through the outskirts in west part and a tank in the north side of the administrative jurisdiction of the town are the limiting factors for the expansion of the town in the northern, western and southern directions.
• Lack of scope of major industries also restricts the scope of development.
• The town falls under CRZ II and development regulations are applicable for these areas.
• Limited Availability of land for development within the town limit necessitates increased density.

3.5.6. Solid waste and wastewater management

Colachel Town generates 5 MT of waste daily on an average. The waste generated comprises of waste from Households, Markets, Commercial Establishments, Hotels and Industries. The waste generated is found to be higher in the core area of the town, where there is concentration of basic services such as Bus stand, Daily Market and Hospitals. The town is also an ‘urban centre’ for the nearby villages, which invites the commercial establishments which generate the waste.

Of the total 5 MT of waste generated, ULB collects 4 MT daily. Door to door daily collection of the waste is yet to be implemented in the town. At present waste collected from the town are dumped in low lying areas and along the coastal side of the town near AVM channel. ULB is planned to purchase 10 acres of land at Salt Pari area to set up solid waste treatment and disposal facility.

Sl. No.	Service Indicator	Unit	Current Status	Normative Standard
1.	Estimated waste generation per capita per day	grams	263	300
2.	Waste collected as estimated by ULB (w.r.t. waste generation)	percent	80	100
3.	Waste collected as per the available capacity (w.r.t. waste generation)	percent	3	--
4.	Road length per conservancy staff	metres	592	500

Table 25 :. Solid Waste Management. Colachel 2008

4. ANALYSIS OF ALTERNATIVES

One of the main objectives of this Initial Environmental Examination assessment is to undertake an **environmental and social analysis of the different alternatives proposed** giving each alternative an environmental and social dimension. The alternatives assessment is based on an estimation of discriminating impacts; i.e. impacts which can distinguish between alternatives.

Hence, common or identical impacts that do not refer to different locations from the ones in the proposed alternatives will not be included in the analysis.

4.1. METHODOLOGY

Based on the following steps:

- Identification of main Project impacts allowing discrimination between the proposed alternatives.
- Identification of synthetic impact magnitude indicators.
- Alternatives assessment.
- Summary of adverse impacts of each alternative.

Once the possible design impacts have been identified, the potential environmental and social effects of every design alternative will be assessed based on the estimation of synthetic impact magnitude indicators, designed to allow discrimination between the different alternatives proposed.

Such indicators will be grouped according to the environmental/social element affected. The values obtained will be included in an alternatives analysis where physical, biotic and social sub-factors will carry different weights.

This process would assign an environmental and social value to every alternative considered, enabling their comparison in terms of environmental and/or social impact.

4.2. NEGATIVE IMPACTS IDENTIFICATION

The objective is to:

- Identify potential impact
- Identifying impacts that can discriminate between the different port locations.

4.2.1. Impacts at the construction phase

	Design component	Environmental/social components likely to be impacted	Brief description of impact	Impact to be considered for the selection of Alternatives
			Construction phase	
1	Breakwater and land reclamation area	Shoreline changes	Changes in erosion and accretion patterns along the coast.	X
			Changes in sediment transport along the coast.	X
2	Dredging	Marine water quality	Increase in turbidity. Change in marine water quality due to aqueous discharges (oily waste, sanitary waste) from dredgers, barges and workboats.	X
		Marine ecology	Removal of benthic communities. Decrease in DO levels. Decrease in species diversity and density in areas adjoining dredging site.	X
3	Construction process. Machinery and vehicle activity, storage of materials.	Air quality	Construction vehicle exhaust emissions and activity. Fugitive dust and suspended dust during construction.	
		Noise	Noise from vehicles, construction machinery and dredger.	
4	New road access, transport of materials	Natural drainage pattern	Disturbance to natural drainage pattern due to road widening.	X
		Vegetation and rural area	Loss of vegetation and agricultural areas due to new roads and widening of existing roads.	X
		Existing infrastructure	Strain on existing infrastructure.	X
5	Water supply	Water resources	Water shortage/pollution.	
6	Waste management	Disposal of solid waste and handling of hazardous waste.	Impacts on water and soil quality.	
7	Inland port facilities. Land acquisition.	Land property	Loss of agricultural land. Loss of natural vegetation, Property loss.	X
8	Port	Fishermen and fishing villages	Impact on fishing due to construction works. Loss of fish landing sites. Decrease in fishing. Loss of livelihood.	X
9	Effect on existing fishing harbour	Movement of fishing boats	Restriction on free movement of fishing boats to/from fishing harbour. Tranquillity in fishing harbour.	X

Table 26 Impacts at Construction Phase

4.2.2. Impacts during the operation phase

	Design component	Environmental/social components likely to be impacted	Brief description of impact	Impact to be considered for the selection of Alternatives
Operation phase				
1	Cargo handling and inland cargo movement and storage areas	Air quality and noise	Due to equipment handling and vehicular movement..	
		Traffic increase	Impact on traffic and traffic networks.	X
2	Aqueous discharges in harbour basin	Marine water quality and ecology	Change in marine water quality/ecology due to discharged ship waste(spillage), sewage, bilge water, solid waste, etc.	
3	Cargo and oil spills	Marine water quality and ecology	Change in marine water quality.	
4	Maintenance dredging	Marine water quality	Increase in turbidity	
		Marine ecology	Due to decrease in DO levels which affect marine ecology and disturbance to benthic communities.	
5	Water supply	Water resources	Impact on existing water resources, especially ground water, shortage.	X
6	Wastewater discharge	Water quality	Impact due to discharge of runoff from container storage and sewage from port and port colony premises.	
7	Solid waste management	Groundwater and soil quality	Impact due to disposal of solid waste on ground without treatment.	
8	Handling of hazardous waste	Marine water quality, marine ecology	Impact due to accidents with hazardous waste and material.	
9	Port activity	Fishermen's livelihood	Impact on fishing due to vessel movement and restriction on free movement of fishing boats.	X

Table 27 Impacts during Operational Phase

The impacts marked with an X in both tables are closely linked to the location and configuration of each port. The following table links each identified impact to the related environmental and social factor and sub-factors.

<table>
<tr><th rowspan="2">No</th><th colspan="3">Environmental / social component</th><th rowspan="2">Design component</th><th rowspan="2">Brief description of impact</th></tr>
<tr><th>Factor</th><th colspan="2">Sub-factor</th></tr>
<tr><td>1</td><td>Coastal geomorphology</td><td colspan="2">Sediment transport, beach dynamics</td><td>Breakwater and land reclamation area</td><td>Changes in erosion and accretion patterns along the coast.</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Marine ecosystems</td><td colspan="2">Marine water quality</td><td rowspan="2">Dredging</td><td>Increase in turbidity. Change in marine water quality due to aqueous discharges (oily waste, sanitary waste) from dredgers, barges and workboats.</td></tr>
<tr><td colspan="2">Marine ecology</td><td>Removal of benthic communities. Decrease in DO levels. Decrease in species diversity and density in areas adjoining dredging site.</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Hydrology</td><td colspan="2">Water resources</td><td>Water Supply</td><td>Impact on existing water resources, especially ground water, shortage.</td></tr>
<tr><td colspan="2">Drainage network</td><td>New road access, transport of materials</td><td>Disturbance to natural drainage pattern due to road widening.</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Vegetation / terrestrial ecosystems</td><td colspan="2">Vegetation in agricultural land</td><td>New road access, transport of materials</td><td>Loss of vegetation and agricultural areas due to new roads and widening of existing roads.</td></tr>
<tr><td colspan="2">Vegetation/land cover</td><td>Inland port facilities. Land acquisition</td><td>Loss of agricultural land. Loss of natural vegetation.</td></tr>
<tr><td rowspan="7">5</td><td rowspan="7">Socioeconomic</td><td colspan="2">Road network</td><td>New road access, material transport</td><td>Strain on existing infrastructure.</td></tr>
<tr><td colspan="2">Land ownership</td><td>Local community</td><td>Property loss, displacement of people.</td></tr>
<tr><td rowspan="3">Fisheries</td><td>Fishermen and fishing villages</td><td>Port location and configuration</td><td>Impact on fishing due to construction works. Loss of fish landing sites. Decrease of fisheries activities .Loss of livelihood</td></tr>
<tr><td>Movement of fishing boats</td><td>Effect on existing fishing harbour</td><td>Restriction on free movement of fishing boats to/ from fishing harbour. Tranquillity in fishing harbour.</td></tr>
<tr><td>Fishermen's livelihood</td><td>Port activity</td><td>Impact on fishing due to vessel movement and restriction on free movement of fishing boats.</td></tr>
<tr><td colspan="2">Tourism</td><td>Port location</td><td>Impact on tourism. Depreciation of tourism areas impacts on cultural heritage and landscape.</td></tr>
<tr><td colspan="2">Coastal planning</td><td>Port location</td><td>Impact on Coastal Zone Management Plan</td></tr>
</table>

Table 28 Impacts Description

4.3. IMPACT DESCRIPTION

4.3.1. Coastal geomorphology

Dredging and reclamation works for the construction of breakwaters may intercept and change littoral processes; particularly sediment transport. The location of a port may cause changes in current patterns and littoral drifts due to the alteration of wave refraction, diffraction and reflection. The change of littoral drift may lead to erosion or accretion in shore zones.

Permanent coastline changes due to a new erosion or accretion imbalance may be expected due to the establishment of the port.

A different choice in the port site and configuration may minimize or maximize those impacts on the shoreline. Site selection and port design should aim to minimize the impact from changes in current patterns and other coastal hydrology elements. Therefore, the specific port location and configuration is the main data used to assess this impact.

- Port location

The level of the impact on the waterfront for each alternative depends on the natural preservation of the affected coastline.
The coastline running from Kanyakumari to 2 Km west of Enayam has been studied. Each section of the coast has been categorized based on its state of preservation as per the following parameters:

Shoreline description		Assigned value per category
RV	River estuary	7
SD	Sandy beach with sand dune vegetation	6
SC	Sandy beach and coconut tree plantation	5
BU	Beach in built-up landscape	4
RMS	RMS walls, high tide line in contact with RMS wall	3
HTL	No backshore, high-tide line next to built-up or degraded areas	2
DB	Degraded beach	1

Table 29 Shoreline description sites and categorisation

To estimate the impact, a buffer impact of 2 km east and west of the port location has been considered.
The value is expressed as:

- Impact on coastal geomorphology= Total area of type of shoreline affected (in hectares) X value assigned to the shoreline (on a scale of 1 to 7)

The impact will be higher for alternatives that affect well preserved coastlines with. Thus, the higher the value of the indicator, the worse the proposed alternative would be.

- <u>Port configuration</u>

Alternative 2 Manavalakurichi includes a bridge connecting the coast (inland port) to the port itself. This bridge can ameliorate the impact on sediment transport and shoreline dynamics. Thus, the final impact for alternative 2 has been considered to be the third part of its previous calculated value.

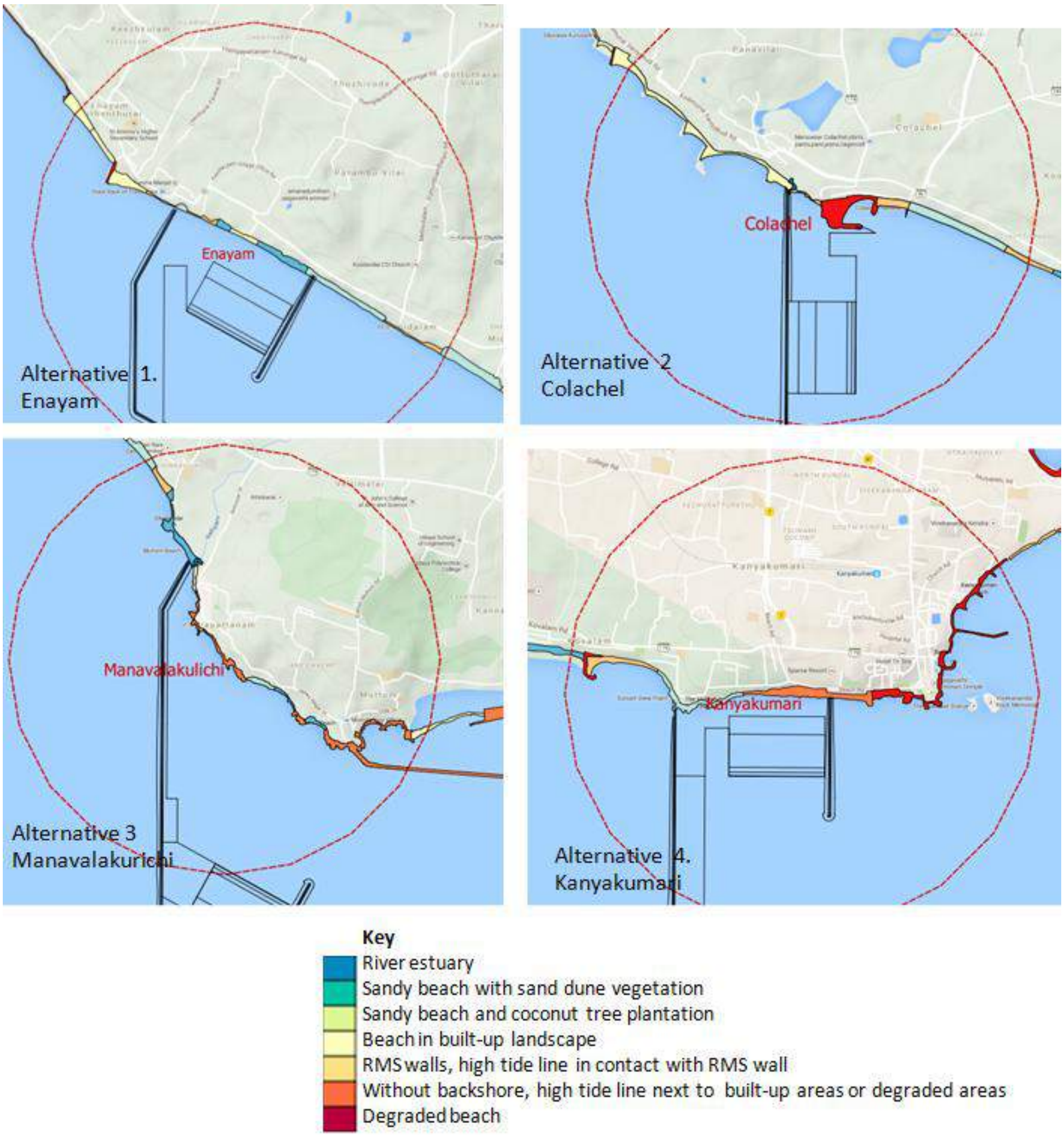


Figure 43. Coastal Geomorphology

Following tables shows the estimation done.

	Alternative	Area (hectare)	Shoreline type	Assigned value	Impact score TOTAL
1	Enayam	0.43	DB	1	0.4
		2.17	RMS	3	6.5
		6.65	BU	4	26.6
		4.72	SC	5	23.6
		3.61	SD	6	21.7
				Total	**78.8**
2	Colachel	7.06	DB	1	7.1
		3.58	RMS	3	10.7
		8.11	BU	4	32.4
		6.42	SC	5	32.1
		0.35	RE	7	2.5
				Total	**84.8**
3	Manavalakurichi	10.00	HTL	2	20.0
		1.36	RMS	3	4.1
		1.8	BU	4	7.2
		1.63	SC	5	8.2
		4.77	SD	6	28.6
		0.42	RE	7	2.9
				Total	71.0
				1/2 of the total	**35.5**
4	Kanyakumari	8.85	DB	1	8.9
		6.38	HTL	2	12.8
		2.99	RMS	3	9.0
		3.66	BU	4	14.6
		0.48	SD	6	2.9
				Total	**48.1**

Table 30 Impacts on Coastal Morphology. Impact magnitude estimation per alternative

Figure 44. Colachel fishing harbour upgrading works and fish landing

Figure 45. Kadiapattinam seafront. Manavalakurichi off-shore Port. Location of the connection bridge. Manavalakurichi beach

Figure 46. Sand stockpiled by Indian Rare Earth limited. Manavalakurichi

Figure 47. Enayam town, west to the stone groyne and east to the stone groyne

Figure 48. Enayam town, RMS wall and beach erosion

Figure 49. Sand dune along the coastline road and coastline road eroded by the sea (Manakudi to Periyakadu)

4.3.2. Marine ecosystems

The location of a port affects aquatic fauna and flora through direct impact on sea-bottom habitats due to land reclamation, breakwaters and changes in water quality and sea-bottom contamination inside the port area and surroundings.

- Land reclamation from the sea destroys bottom habitat and displaces fishery resources.

- Dredging removes bottom biota and dumping of dredged material covers bottom habitat, both of which may reduce fishery resources.
- Deterioration of water quality usually gives rise to changes in aquatic biota: a decrease in the number of species and its abundance.
- Piles, concrete surfaces, rubble mounds and other similar structures in water could form new habitats, which may introduce undesirable species.
- If toxic substances and other contaminants are re-suspended through dredging or dumping, they may lead to contamination of fishery and shellfishery resources.

Judging from the secondary sources of information consulted and from direct interviews with fishermen and local fisheries departments, there is no special differentiation in marine ecosystems for the coastal fringe; thus, ecological components are similar along the coastline studied. Due to currents, sandy substrate and depth, fisheries and marine biota are pelagic and therefore the tidal and shore marine biota are not different between port locations.
Therefore, the total volume of material dredged is the best indicators to use to estimate the impact on the marine ecosystem.

Alternative	Dredging (m3)
1 Enayam	6,230,070
2 Colachel	15,343,819
3 Manavalakurichi	12,805,893
4 Kanyakumari	7,692,053

Table 31 Dredging volume per alternative

4.3.3. Hydrology

Two impacts are likely to occur on terrestrial hydrology:

- Impact on fresh water resources due to water supply during port construction and operation.
- Impact on drainage network due to inland port facilities and new access roads and road widening.

Fresh water sources

Main water source along the coast for the local community is the ground. Major bore wells are fitted with submersible pumps and water is pumped through main pumps to urban areas. In rural areas, water is also pumped from the ground and stored in tanks. Water for irrigation comes from lakes, ponds and open tanks. Currently, fresh water resources are a main concern along the coast.

In the municipality of Colachel, for example, the present water supply needs are partly fulfilled through localized sources like bore wells, which cannot satisfy even the current demand. Hence, in the long term, the sustainable water supply source needs to be increased.

One of the main concerns in coastal aquifers is the intrusion of saltwater into freshwater caused by excessive abstraction of groundwater.

It is preferable to build the proposed port at a location far from urban or densely populated areas to avoid disturbance to fresh water extraction and local overexploitation. Thus, the distance from towns and villages and the surrounding population density is a good indicator of that impact.

Alternative	Surrounded population density	Distance to towns / villages	Impact score (range from 1 to 100)
1 Enayam	Low	0,5 Km	50
2 Colachel	Very High	0 Km	100
3 Manavalakurichi	High	0 Km	70
4 Kanyakumari	Very High	0 Km	100

Table 32 Coastal Aquifers. Distance from town. Impact value categorized.

Drainage network
Regarding the river network, the length of the access roads and the dimension of the inland port are the best indicators to estimate the impact. provided all the alternatives have the same inland expansion, the length of the access roads is:

Alternatives	Lenght (Km)
Alternative 4.1	**3,57**
Alternative 4.2	6,45
Alternative 3.1	15,02
Alternative 3.2	**14,05**
Alternative 2	**11,68**
Alternative 1	**13,51**

Table 33 Length of access roads per alternative.

Figure 50. Road connections to main road (NH 47)

4.3.4. Vegetation, terrestrial ecosystems

A huge terrestrial area will be transformed by port facilities, industries and future expansions. Terrestrial fauna and flora may be altered by the location of a port. Terrestrial ecosystems along the coast are mainly represented by coconut tree plantations, banana plantations, paddy and fruit trees and small horticulture farms,; however, semi-natural ecosystems such as Casuarina plantations and sand dune vegetation are also present. A category of ecological value has been assigned to each identified unit of natural vegetation, terrestrial ecosystem and crop as shown in the next table:

Figure 51. Coconut tree plantation and water pond

Vegetation, cropland units		Assigned value
RV	River	100
WL	Wetland, lakes	100
BS	Beach and shoreline	95
SD	Sand dune vegetation	95
DC	Dense coconut tree area	90
DCSP	Dense coconut tree area - sparsely populated	85
DCFT	Dense coconut and fruit tree area	80
DCFTSP	Dense coconut and fruit tree area - sparsely populated	75
DCFTDP	Dense coconut and fruit tree area - densely populated	70
SCDP	Sparse coconut tree area - densely populated	65
SCFTSP	Sparse coconut and fruit tree area- sparsely populated	60
SCFTDP	Sparse coconut and fruit tree area - densely populated	55
SFT	Sparse fruit tree area	50
HC	Horticulture and other seasonal crops	45
AT	Altered, bare soil, disseminated trees	40
AS	Altered, bare soil	35
PO	Pond	30
UA	Urban area	25

Table 34 Categorized vegetation / cropland units.

- An inland rectangular 2.5 x 2.5 km next to each of the 4 proposed port locations area was selected to obtain the above data on vegetation and crops from which to estimate the impact.
- Impact on vegetation, terrestrial ecosystems = total area (m2) x vegetation unit(i) value+ … + total area (m2) x vegetation unit(j) value;
-

The impact will be higher for those alternatives that affect vegetation and crops of higher ecological importance. Thus, the higher the value of the indicator, the worse the considered alternative would be.
The following images show vegetation and crop units for the 2.5 x 2.5 km2 area for each port location.

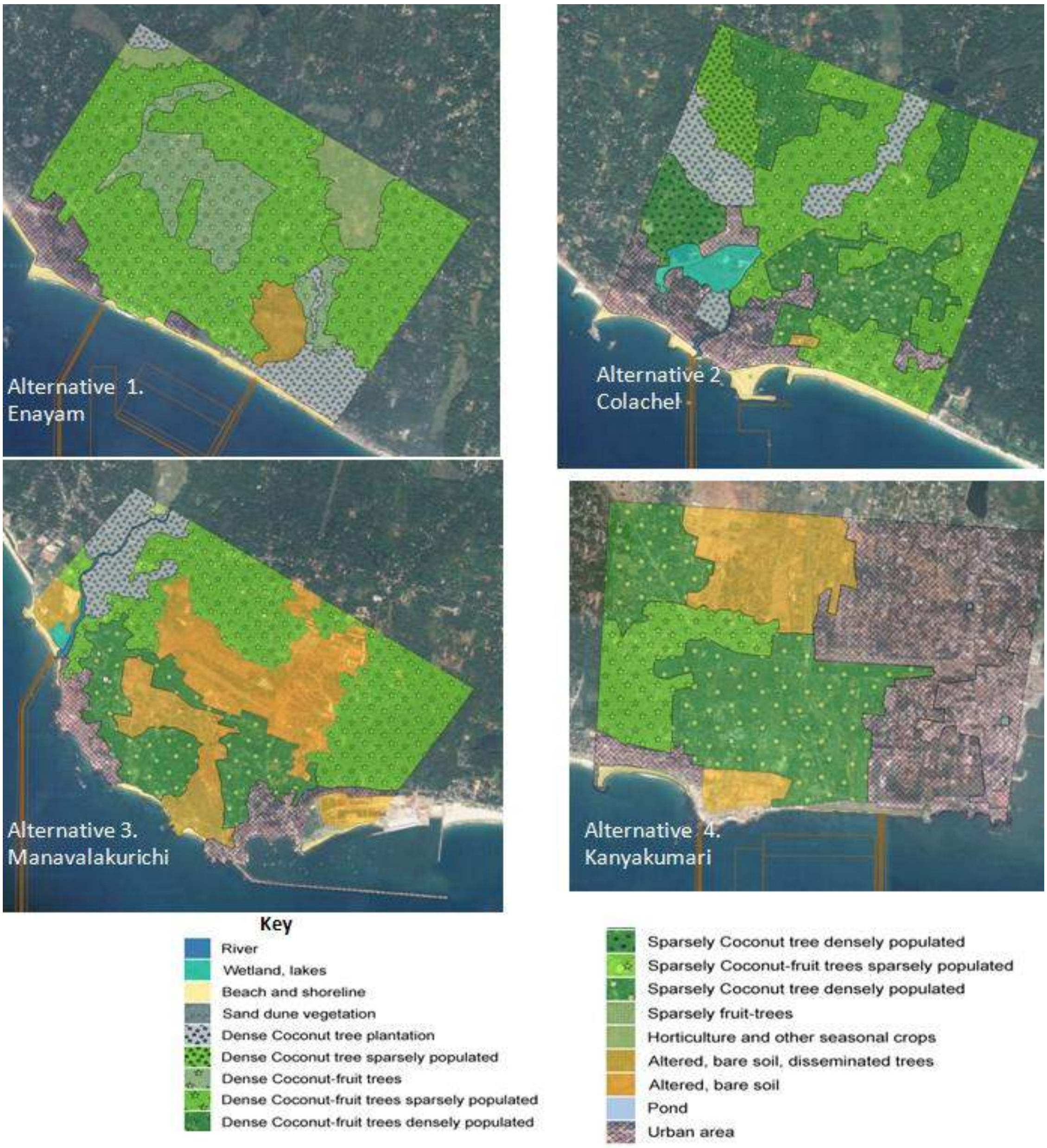


Figure 52. Vegetation and terrestrial ecosystems

Following table shows the estimated impact.

Alternative		Vegetation /cropland unit	Area (hectare)	Assigned value	Impact score TOTAL
1	ENAYAM	BS	17.2	95	1376.6
		HC	9.2	45	414
		DC	41.8	90	3763.8
		UA	33.3	25	831.3
		DT	23	40	920
		DCFT	97.6	80	7809.6
		SFT	35.8	50	1791
		PO	0.7	30	20.7
		DCFTSP	395.1	75	29628.8
					46808.35
2	COLACHEL	BS	19.4	95	1843
		RV	1.3	100	130
		UA	82.8	25	2070
		DC	59.9	90	5391
		WL	19.2	100	1920
		DCFTDP	62.7	70	4389
		DCFTSP	263.4	75	19755
		SCDP	32.2	65	2093
		DCSP	31.8	85	2703
		PO	0.4	30	12
		SCFTDP	80.9	55	4449.5
		DT	2	40	80
					44835.5
3	MANAVALAKURICHI	BS	155.2	95	14744
		HC	1.3	45	58.5
		UA	58.2	25	1455
		DC	45.1	90	4059
		DCFTSP	217	75	16275
		PO	0.8	30	24
		WL	2.4	100	240
		RV	4	100	400
		SCFTDP	117.2	60	7032
		DT	58.2	40	2328
					46615.5

Alternative		Vegetation /cropland unit	Area (hectare)	Assigned value	Impact score TOTAL
4	KANYAKUMARI	BS	34.4	95	3268
		UA	270	25	6750
		DCFTSP	69.4	75	5205
		DT	84.2	40	3368
		SCFTDP	195.5	55	10752.5
		PO	0.5	30	15
					29358.5

Table 35 Estimated impact onto vegetation per alterntives.

Figure 53. Valliyar estuary formed by the river Valloiyar nearManavalakurichi. Paddy landscape. Manavalakurichi-Nagercoil road

Figure 54. Casuarina plantations on sand dunes. Manakudi. Shipyard near the coast. Enayam

4.3.5. Socio-economic

4.3.5.1. Impacts on the transport network

Transporting huge quantities of construction material for the breakwaters, berths, operation, administrative and welfare buildings, for land filling/development, storage and stacking yards and others, during the construction phase, as well as transporting cargoes to/from the port during the port operation phase may result in excessive use of existing public infrastructure like roads, railways and inland waterways, resulting in congestion and early ageing, to name a few effects. Currently, the road network supports a high volume of traffic, with some sections that need repairs and improvements. In particular, the crossing at Nagercoil has frequent traffic jams and delays. The road length impacted and the number of villages and towns crossed are good indicators of this impact.

Alternative	Access road length to major road	Number of villages crossed	Assigned Impact score (range from 1 to 100)
1 Enayam	13,51	4	50
2 Colachel	11,68	5	60
3 Manavalakurichi	14,05	6	75
4 Kanyakumari	3,57	1	20

Table 36 Estimated impact on transport network per alternative .

4.3.5.2. Impacts on land ownership and population displacement

The port will need an extra inland area; although it has not yet been clearly defined, we can assume its area will stand between 1.5 and 2 km2. The future expansion of inland port-related activities such as industries may create the need for extra areas which may impact on the population and on private property. Relocation of the local community may cause conflicts with local people.

The impact on private land or property as a result of land acquisition is linked to population density. The impact can be minimized by selecting areas with low population or by including state-owned land. In order to estimate the impact, the population density has been estimated for a selected 2.5 x 2.5 km2 square inland area next to the proposed port for each of the 4 locations. Population density has been estimated through aerial photography and fieldwork surveys. The following maps show inland population density within the 2.5 x 2.5 km2 area for each port location.

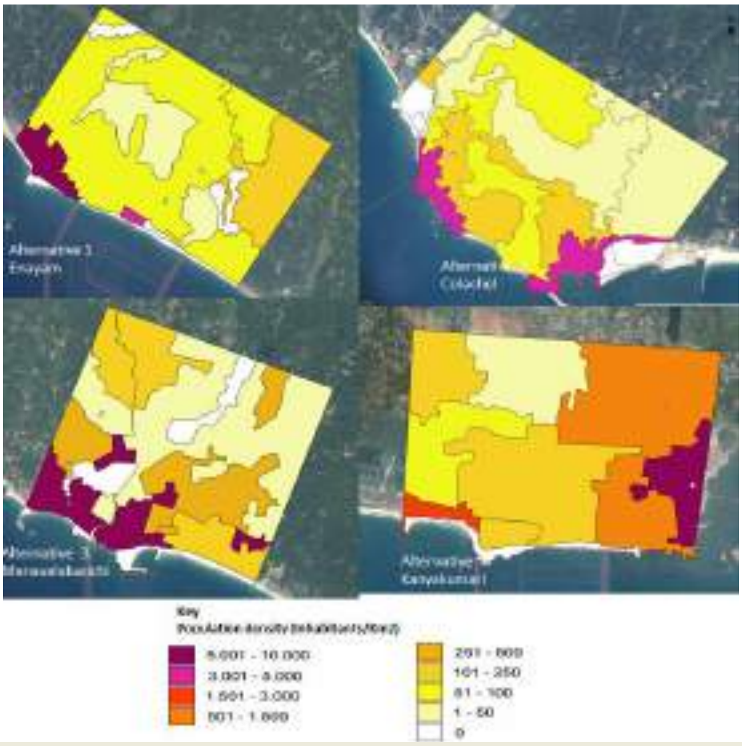


Figure 55. Population density

Following table shows the estimation done:

Alternative		Area (Km2)	No. of Households	Households/ Km2
1. Enayam	Rural	6.2	384	**326**
	Urban	0.33	1746	
	Total	6.54	**2130**	
2. Colachel	Rural area	5.79	719	**827**
	Urban area	0.77	5427	
	Total	6.56	**6146**	
3. Manavala kurichi	Rural area	6.01	372	**441**
	Urban area	0.58	2.36	
	Total	6.59	**2908**	
4. Kanyakumari	Rural area	3.84	322	**652**
	Urban area	2.7	3942	
	Total	6.54	**4264**	

Table 37 Estimated impact on households per alternative

4.3.5.3. Fishing activities

The port can impact directly on the fishing activity depleting fish landing areas, fishing ports, fishing jetties, etc. The proposed port can have an impact on navigation for fishing activities since fishing boats may have to divert or lengthen their route to the fishing banks because of the port. Also, altered currents or reflected waves may endanger small ship manoeuvring near structures.

The creation of a port may cause changes in beach erosion with the deterioration of coast landing sections. The loss of sections of the coast used by local community for fish and boat landing may cause a direct impact on family incomes and livelihood.

Impacts can be summarized as: Effect on the existing fishing harbour and land fishing sections, deterioration of fishing activities.

Figure 56. Mechanized boats in the Colachel fishing harbor and fishermen at Midalam beach


Figure 57. Tuna fish catch. Colachel. Prawns catch. Colachel


Figure 58.Kanyakumari fish landing site. Kanyakumari fish market

To assess those impacts, all the coastal fishing sites have been identified through secondary sources of information (statistics, Tamil Nadu fishing sector reports), field surveys and aerial photography.

Fishing sites have been categorised as:

The estimated impact is based on the following characteristics:

I. Direct and indirect impact on coastal fishing sites within a 2 km buffer area, and
II. a previous valuation of each fishing site based on its configuration and facilities for fishing activities.

The number of catamarans, boats and mechanized boats for each site affected has been estimated by aerial photography. The indicator is expressed as:

- Impact on fishery

  Impact value= Type of fish landing site affected x (No of catamarans and No of mechanized boats affected+ 10 x No of mechanized boats affected) x nature of impact

Nature of impact	Assigned value
Direct impact	5
Indirect impact	1

Type of fish landing site	Assigned value

Open fish landing site	1
Fish landing site protected by groyne(s)	2
Small fishing harbour	3
Fishing harbour for mechanized boats	4

The following table shows an estimate of impacts for each alternative.

id	Alternatives	Type of fish landing site affected	No. Of catamarans and no mechanized boats	No. Of mechanized boats	Nature of Impact	Impact value	Impact score
44	Enayam	1	32	0	1	32	1170
45		1	41	0	5	205	
46		1	5	0	5	25	
47		2	162	0	1	324	
48		2	292	0	1	584	
34	Colachel	1	16	0	1	16	1557
35		3	243	13	1	1119	
36		2	32	0	5	320	
37		2	29	0	1	58	
38		2	22	0	1	44	
27	Manavalakurichi	3	220	0	1	660	1145
28		1	40	0	1	40	
29		1	85	0	5	425	
30		1	20	0	1	20	
3	Kanyakumari	2	8	0	1	16	881
4		2	26	0	1	52	
5		3	49	3	1	237	
6		3	56	0	1	168	
7		3	17	0	1	51	
8		3	27	3	1	171	
9		2	93	0	1	186	

Table 38 Estimated impact on fishing activities per alternative.

Following image shows identified impacts on Fish landing sites and harbours:

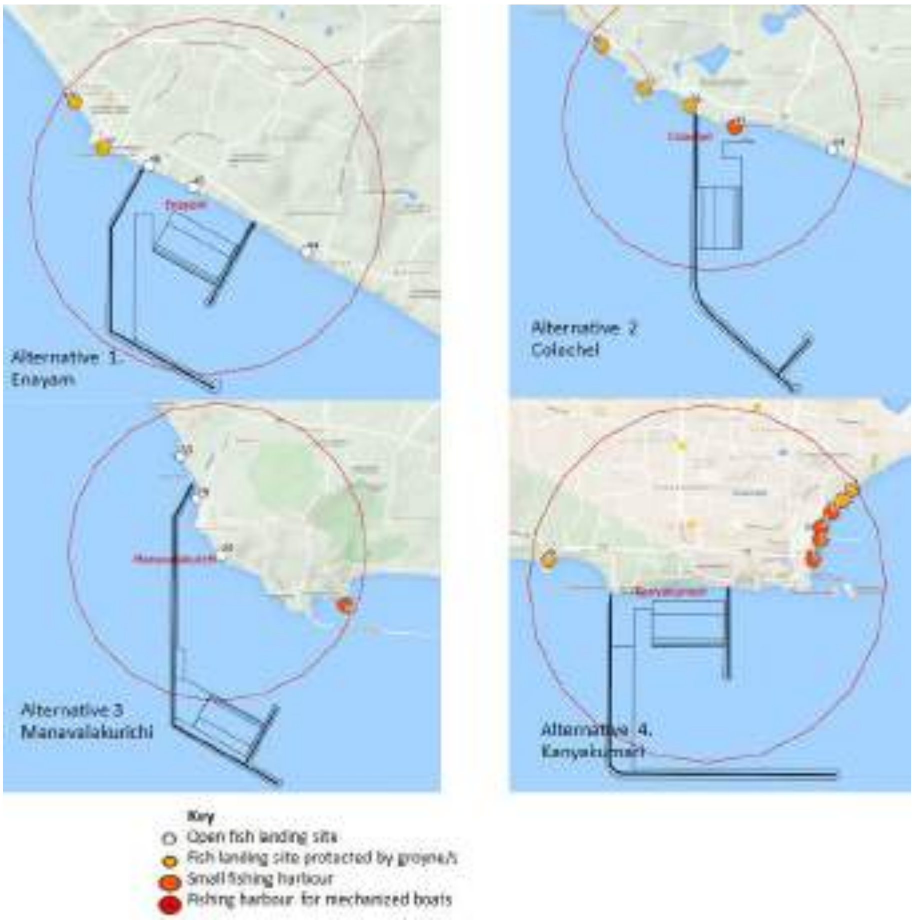


Figure 59. Impacts on Fish landing sites and harbours

4.3.5.4. Tourism

The visual quality of a project area is affected by the creation of a port, port facilities, lighting, and other optical disturbances. The landscape may be changed into an artificial industrial scene. Some port facilities may give an unpleasant impression to people.

One major feature and tourist attraction lies on the west coast of Tamil Nadu: Kanyakumari town, one of nine major tourist attraction areas in Tamil Nadu, notable for its pilgrimage and tourism. A total of 1.6 million tourists (96.7 % domestic visitors) visited Kanyakumari in 2010.

Specific studies show that tourism development in Kanyakumari may bring millions of tourists, generating much income and boosting the local economy and improving local society.

The most important places are: Thiruvalluvar Statue, Vivekananda Rock Memorial, Kamarajar Manimandapam, Mahatama Gandhi Memorial and Bay Watch.

Another major cultural site is Colachel town, declared a heritage town (G.O. Ms. No. 191 MA&WS department dated 18.07.1994).

Tourism developments along the coastline are also present in Muttom and between Manakudi and Pallam.

A qualitative approach has been used to assess the impact on tourism and tourism development.

Taking into account the above paragraphs, the following table gives estimation of the impact on the 4 port locations proposed.

Alternative	Qualitative Impact score (range 1 to 100)
1 Enayam	10
2 Colachel	70
3 Manavalakurichi	40
4 Kanyakumari	100

Table 39 Estimated impact on tourism activities per alternative.

Figure 60.Kannyakumari: Sunset point

Figure 61.Colachel Town. Thiruvalluvar Statue and Kanyakumari temple.

4.3.5.5. Coastal and maritime planning

According to the 2011 CRZ Notification, the land area falling between the hazard line and 500 meters from HTL on the landward side, for the seafront, and between the hazard line and 100-meter line for tidally influenced water bodies was also declared a Coastal Regulation Zone (CRZ). The notification set restrictions on the setting up and expansion of industries, operations or processes and the like in the CRZ. For the purposes of conserving and protecting the coastal areas and maritime waters, the CRZ area is classified as CRZ-I, CRZ-II, CRZ-III and CRZ-IV.

CRZ-I,– A. The areas that are ecologically sensitive and the geomorphological features which play a role in the maintaining the integrity of

the coast,
(a) Mangroves, in case mangrove area is more than 1000 sq mts, a buffer of 50meters along the mangroves shall be provided;
(b) Corals and coral reefs and associated biodiversity;
(c) Sand Dunes;
(d) Mudflats which are biologically active;
(e) National parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas under the provisions of Wild Life (Protection) Act, 1972 (53 of 1972), the Forest (Conservation) Act, 1980 (69 of 1980) or Environment (Protection) Act, 1986 (29 of 1986); including Biosphere Reserves;
(f) Salt Marshes;
(g) Turtle nesting grounds;
(h) Horse shoe crabs habitats;
(i) Sea grass beds;
(j) Nesting grounds of birds;
(k) Areas or structures of archaeological importance and heritage sites.
CRZ-I- B. The area between Low Tide Line and High Tide Line;

Identifying the impacts on CRZ-I – A areas due to port location can be useful to the alternatives assessment. A draft version map of the Coastal Zone Management Plan of Tamil Nadu (CZMPTN) Kanyakumari district was provided by the Assistant Engineer of the Tamilnadu Pollution Control Board (Nagercoil). Although a draft version map, it gives detailed information of CRZ areas along the studied coast section.
The following CZMPTN maps show the CRZ-I-A sensitive areas:

- Areas of archaeological importance and heritage sites in Kanyakumari town.
- Colachel River estuary.

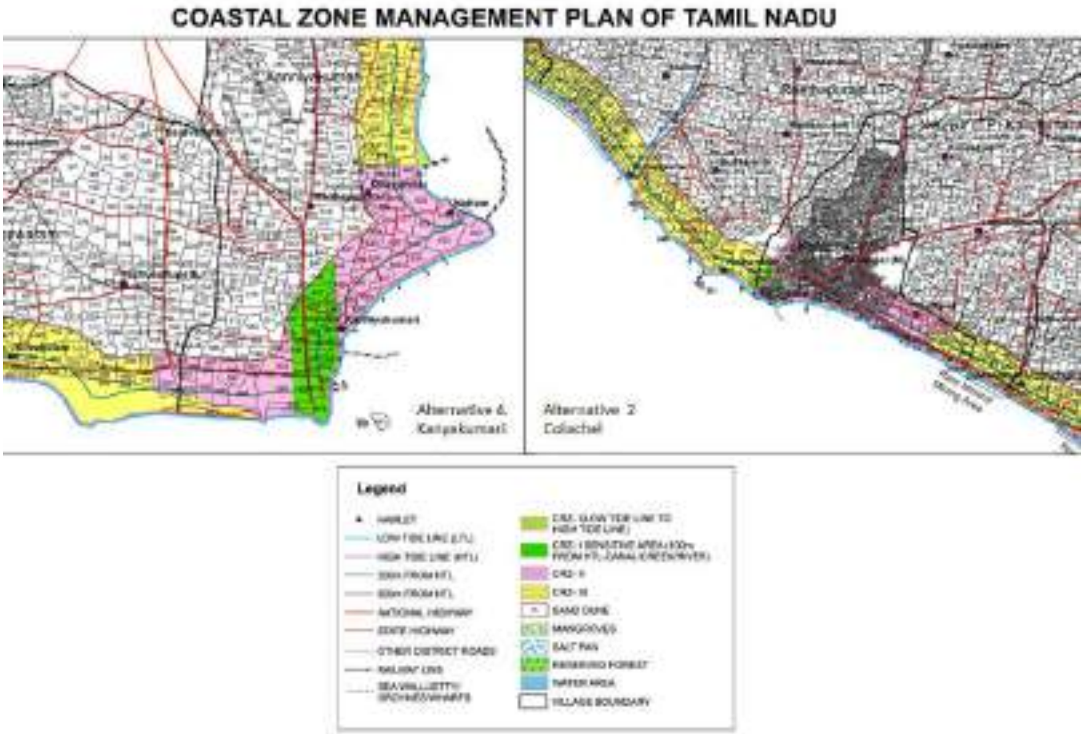


Figure 62: Coastal zone management Plan of Tamil Nadu

Thus, an impact score can be assigned to each alternative for predicted impacts on CRZ sensitive areas:

Alternative	Qualitative impact score (range 1 to 100)
4 Enayam	0
3 Colachel	70
2 Manavalakurichi	0
1 Kanyakumari	100

Table 40 Estimated impact on Coastal Management (CRZ sensitive areas) per alternative.

4.4. IMPACTS EVALUATION

4.4.1. Gross impacts evaluation

The following table summarizes the estimated adverse impacts on each alternative.

Estimated adverse impacts on each alternative.

Factors	Sub-factor	Adverse Impact	Estimated Impact score – Alternatives: 1 Enayam	2 Colachel	3 Manavala kurichi	4 Kanyakumari
Coastal geomor - phology	Sediment transport, beach dynamics	Changes in erosion and accretion patterns along the coast	78,8	84,8	35,5	48,1
Marine ecosystems	Marine water quality	Increase in turbidity. Change in marine water quality due to aqueous discharges	6230070	15343819	12805893	7692053
	Marine ecology	Removal of benthic communities. Decrease in species diversity				
Hydrology	Water resources	Impact on existing water resources, specially ground water, scarcity	50	100	70	100
	Drainage network	Disturbance to natural drainage pattern due to road widening	13,5	11,6	14	3,5
Vegetation/ terrestrial ecosystems	Vegetation/ land cover	Loss of agricultural land. Loss of natural vegetation,	46808,3	44835,5	46615,5	29358,5
Socio - economic	Road network	Strain on existing infrastructure	50	60	75	20
	Land ownership	Properties loss, displacement of people	2130	6146	2908	4264
	Fisheries	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	1170	1557	1145	881
	Tourism	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	10	70	40	100
	Coastal Planning	Impact on CRZ-I areas	0	70	0	100

Table 41 Estimated adverse impacts valuation per alternative.

The evaluation process for analyzing the environmental and social impact of the proposed alternatives and reaching a single impact score is the following:

- Homogeneous evaluation. Convert the estimated impact data to a 0-100 range.

<table>
<tr><th colspan="7"><u>Estimated impact ranged to a 0-100 interval</u></th></tr>
<tr><th rowspan="3">Factors</th><th rowspan="3">Sub-factor</th><th rowspan="3">Adverse Impact</th><th colspan="4">Estimated Impact score</th></tr>
<tr><th colspan="4">Alternatives</th></tr>
<tr><th>1 Enayam</th><th>2 Colachel</th><th>3 Manavala kurichi</th><th>4 Kanyakum ari</th></tr>
<tr><td>Coastal geomor - phology</td><td>Sediment transport, beach dynamics</td><td>Changes in erosion and accretion patterns along the coast</td><td>92,9</td><td>100,0</td><td>41,9</td><td>56,7</td></tr>
<tr><td rowspan="2">Marine ecosystems</td><td>Marine water quality</td><td>Increase in turbidity. Change in marine water quality due to aqueous discharges</td><td rowspan="2">40,6</td><td rowspan="2">100,0</td><td rowspan="2">83,5</td><td rowspan="2">50,1</td></tr>
<tr><td>Marine ecology</td><td>Removal of benthic communities. Decrease in species diversity</td></tr>
<tr><td rowspan="2">Hydrology</td><td>Water resources</td><td>Impact on existing water resources, specially ground water, scarcity</td><td>50,0</td><td>100,0</td><td>70,0</td><td>100,0</td></tr>
<tr><td>Drainage network</td><td>Disturbance to natural drainage pattern due to road widening</td><td>96,4</td><td>82,9</td><td>100,0</td><td>25,0</td></tr>
<tr><td>Vegetation/ terrestrial ecosystems</td><td>Vegetation/ land cover</td><td>Loss of agricultural land. Loss of natural vegetation,</td><td>100,0</td><td>95,8</td><td>99,6</td><td>62,7</td></tr>
<tr><td rowspan="5">Socio - economic</td><td>Road network</td><td>Strain on existing infrastructure</td><td>66,7</td><td>80,0</td><td>100,0</td><td>26,7</td></tr>
<tr><td>Land ownership</td><td>Properties loss, displacement of people</td><td>34,7</td><td>100,0</td><td>47,3</td><td>69,4</td></tr>
<tr><td>Fisheries</td><td>Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities</td><td>75,1</td><td>100,0</td><td>73,5</td><td>56,6</td></tr>
<tr><td>Tourism</td><td>Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape</td><td>10,0</td><td>70,0</td><td>40,0</td><td>100,0</td></tr>
<tr><td>Coastal Planning</td><td>Impact on CRZ-I areas</td><td>0,0</td><td>70,0</td><td>0,0</td><td>100,0</td></tr>
</table>

Table 42 Estimated adverse impacts valuation per alternative. Homogeneous evaluation

- Carry out a sensitive analysis based on different weightings of the estimated impacts:
  I. Environmental and social factors weigh the same. 50%-50%
  II. All the environmental and social sub-factors weigh the same, i.e. all the adverse impacts weigh the same.
  III. A different weight is given to factors and sub-factors, i.e. to the adverse impacts, based on an expert judgement.

The following tables shows the results:

Sensitive analysis 1: Environmental and social factors weigh the same. 50%-50%

Factors	Weights	Sub-Factors	Weights	Adverse Impact	1 Enayam	2 Colachel	3 Manavala kurichi	4 Kanyakum ari
					Estimated Impact score – Alternatives			
Coastal geomor - phology	0,5	Sediment transport, beach dynamics	0,125	Changes in erosion and accretion patterns along the coast	11,8	12,5	5,2	7,1
Marine ecosystems		Marine water quality	0,125	Increase in turbidity. Change in marine water quality due to aqueous discharges	5,1	12,5	10,4	6,3
		Marine ecology		Removal of benthic communities. Decrease in species diversity	0,0	0,0	0,0	0,0
Hydrology		Water resources	0,063	Impact on existing water resources, specially ground water, scarcity	3,1	6,3	4,4	6,3
		Drainage network	0,063	Disturbance to natural drainage pattern due to road widening	6,0	5,2	6,3	1,6
Vegetation/ terrestrial ecosystems		Vegetation/ land cover	0,125	Loss of agricultural land. Loss of natural vegetation,	12,5	12,0	12,4	7,8
Socio - economic	0,5	Road network	0,100	Strain on existing infrastructure	6,7	8,0	10,0	2,7
		Land ownership	0,100	Properties loss, displacement of people	3,5	10,0	4,7	6,9
		Fisheries	0,100	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	7,5	10,0	7,4	5,7
		Tourism	0,100	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	1,0	7,0	4,0	10,0
		Coastal Planning	0,100	Impact on CRZ-I areas	0,0	7,0	0,0	10,0
					67,0	**90,4**	**64,8**	**64,3**

Table 43 Estimated adverse impacts valuation per alternative. Sensitive analysis I

Sensitive analysis 2: All the environmental and social sub-factors weigh the same

Factors	Sub-factor	weights	Adverse Impact	1 Enayam	2 Colachel	3 Manavala kurichi	4 Kanyakum ari
				Estimated Impact score – Alternatives			
Coastal geomor - phology	Sediment transport, beach dynamics	0,09	Changes in erosion and accretion patterns along the coast	8,4	9,0	3,8	5,1
Marine ecosystems	Marine water quality	0,09	Increase in turbidity. Change in marine water quality due to aqueous discharges	3,7	9,0	7,5	4,5
	Marine ecology	0,09	Removal of benthic communities. Decrease in species diversity	0,0	0,0	0,0	0,0
Hydrology	Water resources	0,09	Impact on existing water resources, specially ground water, scarcity	4,5	9,0	6,3	9,0
	Drainage network	0,09	Disturbance to natural drainage pattern due to road widening	8,7	7,5	9,0	2,3
Vegetation/ terrestrial ecosystems	Vegetation/ land cover	0,09	Loss of agricultural land. Loss of natural vegetation,	9,0	8,6	9,0	5,6
Socio - economic	Road network	0,09	Strain on existing infrastructure	6,0	7,2	9,0	2,4
	Land ownership	0,09	Properties loss, displacement of people	3,1	9,0	4,3	6,2
	Fisheries	0,09	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	6,8	9,0	6,6	5,1
	Tourism	0,09	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	0,9	6,3	3,6	9,0
	Coastal Planning	0,09	Impact on CRZ-I areas	0,0	6,3	0,0	9,0
			TOTAL	**51,0**	**80,9**	**59,0**	**58,2**

Table 44 Estimated adverse impacts valuation per alternative. Sensitive analysis II

Sensitive analysis 3: Expert judgement

Factors		Sub-factor		Adverse impact	Estimated Impact score			
					Alternatives			
	weights		weights		1 Enayam	2 Colachel	3 Manavalakurichi	4 Kanyakumari
Coastal geomorphology	0,2	Sediment transport, beach dynamics	0,2	Changes in erosion and accretion patterns along the coast	13,9	15,0	6,3	8,5
Marine ecosystems	0,15	Marine water quality	0,15	Increase in turbidity. Change in marine water quality due to aqueous discharges	8,1	20,0	16,7	10,0
		Marine ecology	0	Removal of benthic communities. Decrease in species diversity				
Hydrology	0,1	Water resources	0,05	Impact on existing water resources, specially ground water, scarcity	2,5	5,0	3,5	5,0
		Drainage network	0,05	Disturbance to natural drainage pattern due to road widening	4,8	4,1	5,0	1,3
Vegetation/ terrestrial ecosystems	0,2	Vegetation/ land cover	0,2	Loss of agricultural land. Loss of natural vegetation.	15,0	14,4	14,9	9,4
Socio - economic	0,35	Road network	0,04	Strain on existing infrastructure	3,3	4,0	5,0	1,3
		Land ownership	0,07	Properties loss, displacement of people	3,5	10,0	4,7	6,9
		Fisheries	0,1	Impact on fishing . Loss of fish landing sites. Decrease of fisheries activities	7,5	10,0	7,4	5,7
		Tourism	0,07	Impact on tourism. Depreciation of tourism areas, impact on cultural heritage and landscape	1,0	7,0	4,0	10,0
		Coastal Planning	0,07	Impact on CRZ-I areas	0,0	3,5	0,0	5,0
				TOTAL	59,7	93,0	67,5	63,1

Table 45 Estimated adverse impacts valuation per alternative. Sensitive analysis III

The following table and chart summarize the results:

Analysis	Estimated Impact score			
	Alternatives			
	1 Enayam	2 Colachel	3 Manavalakurichi	4 Kanyakumari
All the factors weight the same	51,0	80,9	59,0	58,2
Environmental and social factors weights the same	57,0	90,4	64,8	64,3
Expert judgement.	59,7	93,0	67,5	63,1
Average value	55,9	88,1	63,8	61,9

Table 46 Total estimated adverse impacts score per alternative

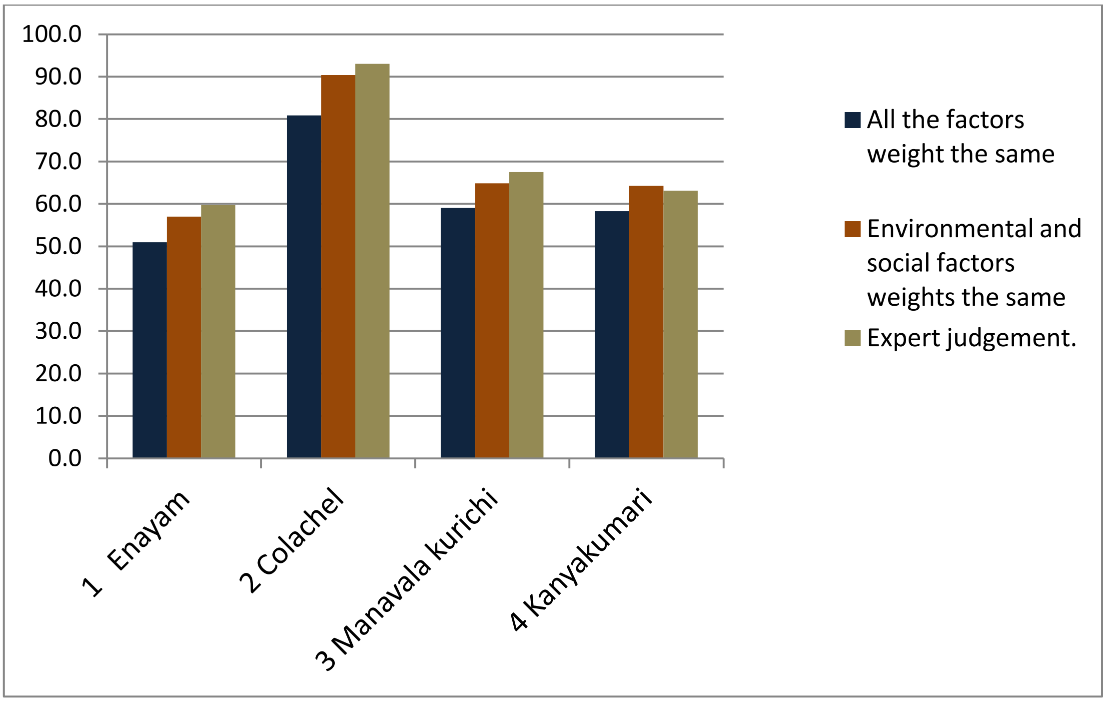


Figure 63. Results from the Sensitive analysis.

4.5. CONCLUSIONS

The best rated alternative location, with the lowest impact, is Enayam, while the worst rated one, with the highest impact, is Colachel. Kanyakumari and Manavalakurichi obtained similar intermediate ratings. The Enayam location has lower environmental impacts than the others with respect to dredging, cultural sites and its low impact on property due to its low population. Port expansion will not need a wide extra inland area since the land reclamation area will provide room for port facilities and industries.

The Manavalakurichi location has lower environmental impacts than Kanyakumari with respect to, tourism and cultural sites and lower environmental impacts. Manavalakurichi has lower environmental impacts than Enayam with respect to coastline and fishing. This is due to its special configuration whereby the port is not attached to the coastline and connects inland via a bridge that allows the transport of sediments and therefore has a lower effect on coastal processes. Its inland population density which could be affected by the expansion of the port is lower than in Colachel and Kanyakumari.

The Kanyakumari location was better rated in regards to its proximity to the transport network and because the coastline is more poorly preserved. In any case, a more in-depth weighting of the touristic and cultural factor would rule out this option.

The Colachel location is the worst rated due to its possible impact on the surrounding beaches, which are in an suitable state of preservation and where there is fishing. The beach located to the east of the port location would become a pocket beach, retaining its sand and quality, but would be disconnected from the natural coastal dynamics. In addition, the port is located right next to the heritage town of Colachel, with a dense population and therefore with the potential to impact on underground water resources

5. SCREENING OF POTENTIAL IMPACTS AND MITIGATION MEASURES

From the previous analysis of main the environmental characteristics of the territory and once the best alternative has been chosen, the present chapter will analyze its main component to address the main environmental impacts expected with the implementation and operation of the Enayam option and the recommended mitigation measures.

Thus, the screening of the potential impact analysis will follow the main components of the environment , land, water and socioeconomic environments, and the effects of the proposed port solution onto them.

5.1. LAND ENVIRONMENT

5.1.1. Air quality

5.1.1.1. Transportation and Cargo Material

Some of the project activities (site clearance, dredging and reclamation, construction of breakwaters, construction of port infrastructure, traffic during construction and use of heavy machinery construction of road and rail) will generate air pollutants like NO_2, SO_2, HC, CO, PM, VOCs, etc. This has the potential to cause temporary impacts on the air quality.

According previous studies, the baseline concentrations of Particulate Matter, SO_2, NO_2 and CO are within the limits of NAAQS stipulated by MoEF/CPCB. With the present background concentrations of air quality parameters, it is expected that there will only be a mild build-up of air pollutants. Further, because of the prevailing strong winds along the coastal region and the resulting dispersion the impact on air quality from pollutants would be reduced. Towards land ward side all is green with complete coverage of coconut and other trees (green barrier) will also nullify any air pollution impacts. In addition, adoption of suitable mitigation measures will ensure that these impacts are rendered insignificant.

The following activities may cause air pollution during construction phase:

- Material sourcing at Quarry
- Material and equipment transport
- Stone crushing operations in the crushers;
- Handling and storage of construction material;
- Concrete batching plants;
- Asphalt mix plants due to mixing of aggregates with bitumen; and
- Construction and allied activities.

5.1.1.2. Quarrying

Will be necessary quarrying blasting, drilling, digging, road transport, use of heavy machinery for hauling and loading, storage and handling of fuels, etc. This will generate dust and other air pollutants like NO_2, SO_2, HC, CO, PM. This will affect the ambient air quality.

The choice the quarry site will avoiding nuisance for the public is required. Prior to commencing the works the contractor should establish the environmental baseline conditions in the specific area around the selected quarry.

Monitoring from the beginning of the production should indicate whether standards are exceeded and early action is required.

The proximity of the human settlements should be taken in consideration regarding air (among others) impacts. Particulate Matter (PM), including breathable suspended particulate matter (RSPM) is generated during all phases of exploitation and processing from fugitive sources. The main sources of PM emissions include crushing–grinding, drilling, blasting, and transport. Impacts from PM emissions are related to its size, its main components, as well as to rock impurities and trace components.

During the quarrying activities it is expected that PM will be generated constantly and hence potentially impact the local air quality. Climatologic circumstances such as wind will determine the dispersion patterns. Rock impurities and components need to be checked and monitored by the contractor.

Furthermore, the ambient air quality is affected by the combustion by-products that are emitted by vehicles and other combustion sources installed in the quarrying sites. Toxic and nontoxic gases are normal by-products generated by blasting activities, regardless of the explosive materials used.

5.1.1.3. - Dust Generation

Construction stage impacts will be of short term but have adverse impacts on the construction workers as well as the settlements adjacent to the road and rail alignment, especially those in the down wind direction.

Generation of dust is the most likely impact during this stage due to:

- Site clearance and use of heavy vehicles and machinery, etc.
- Procurement and transport of raw materials and quarries to construction sites
- Dust/ air pollution is likely to be generated due to the various construction activities including: stone crushing operations in the crushers; handling and storage of aggregates in the asphalt plants; concrete batching plants; asphalt mix plants due to mixing of aggregates with bitumen; and construction and allied activities

Generation of dust is generally a critical issue in road /rail projects and is likely to have adverse impact on health of workers in quarries, borrow areas and stone crushing units. All these could be located away from the alignment. This is a direct adverse impact, which will last almost throughout the construction period.

The Environmental Action Plan should lay emphasis on enforcement of measures such as provision of pollution masks, regular sprinkling of water to suppress dust along haul roads at quarries, crushers and borrow areas to mitigate this impact.

Generation of exhaust gases is likely during the preconstruction stage during movement of heavy machinery, oil tankers, etc. This impact is envisaged to be insignificant during the preconstruction stage. High levels of SO_2, HCs are likely from hot mix plant operations.

Volatile toxic gases are released through the heating process during bitumen production. Although the impact is much localized, it can spread downwind depending on the wind speeds. The Environment Management Action Plan (EMAP) needs to ensure adequate measures especially for health and safety of workers such as providing them with pollution masks during working hours. Also, the contractor will be ensured that hot mix plants, stockyards, etc. are away from residential areas and residential quarters of all workers. Contractors also should be asked to provide regularly certificate for their vehicle mounted equipments and machinery as per prevalent. If adequate measures are taken, then impacts from generated gases can be negligible.

5.1.1. Noise Pollution

Construction noise will result from operation of equipment including the dredger and associated tugs, piling equipment, tracked excavators, Lorries, dump trucks, and other earth-moving equipment, cranes, and generators / lighting equipment. Noise nuisance during construction depends on the exact place of the receptor and of the source and the duration of the activity. In touristic areas it is considered high, especially as the ambient noise level for the settlements is high.

Noise pollution may result from the quarrying activities. The main noise sources are associated with drilling, breaking, crushing and handling, screening and transport. The blasting of rocks during quarrying will generate additional noise, besides the regular quarrying machinery.

The most significant vibration emission will be associated with blasting activities. Minor vibrations will be associated with use of rock hammers.
Contractor to make an contractors EMP for all major aspects of pollution including for noise. Prior to commencing the works, the Contractor should establish the baseline conditions for noise in the specific area around the selected quarry.

Monitoring right from the beginning of the production should indicate whether standards are exceeded and early action is required.
The noise and vibration generated by piling in water if not controlled and monitored properly, can be transmitted considerable distances through the water and therefore have the potential to impact on marine mammals. Such noise pollution may cause nuisances to the population. Seawater is an efficient medium for sound propagation, particularly low frequency sound and therefore marine life over a wide area could be potentially affected. Underwater noise during the port construction will result from the equipment that are used for underwater activities, such as dredging, reclamation or the construction of the walls, piling and ship movements.

Atmospheric conditions that may affect noise levels include humidity, wind direction, and wind speed.

Also dredging is likely to occur 24 hours a day, seven days per week. While dredging activities will generate noise from a variety of sources, the primary sources of equipment noise would include the cutter suction dredger itself, with its associated pumps and generators and the tugboats used to position the dredger. Other equipment such as the crew boats and survey boats would not contribute substantially to the noise associated with the dredging activities. Additionally, noise will be generated by onshore plant used to spread the dredged materials and to assemble and periodically relocate pipelines. Generally speaking, a weighted noise intensity from working engines at the noise source shall not exceed a continuous level above approximately 120 dB(A).

Seawater is an efficient medium for sound propagation, particularly low frequency sound and therefore marine life over a wide area could be potentially affected. Underwater noise during the port construction will result from the equipment that are used for underwater activities, such as dredging, reclamation or the construction of the bund wall, piling and ship movements. The noise and vibrations generated by the underwater activities can potentially be transmitted to considerable distances through the water and hence cause negative impacts on the marine mammals. Conditions that determine the transmission of noise emissions and vibrations are current pattern and strength and the hydrological/geomorphologic circumstances. The day to day terminal activities such as vessel loading / unloading, container handling, etc. will cause additional underwater noise emissions. These are however not expected to be significant.

As for railway and access roads construction, traffic both along the rail and road will be primarily due to port development and in first phase, one or two container trains run per day. Nevertheless there will be some level of Noise quality impacts along the project corridor in construction. Construction stage impacts will be of short term but have adverse impacts on the construction workers as well as the settlements adjacent to the road and rail alignment, especially those in the down wind direction.

Noise created during construction activities may force birds to temporarily migrate to others places. During the construction stage, crusher, sets and mixture machine and diversion of traffic will lead to rise in noise level, ultimately results in increase in the ambient noise quality. However, the impacts during construction are short-term in nature and will cease on completion of the construction.

Impacts during operations mainly will result from the port terminal activities such as vessel loading/unloading, container handling and access road/rail traffic that will result from container traffic arriving and departing through the port business day. Seawater is an efficient medium for sound propagation, particularly low frequency sound and therefore marine life over a wide area could be potentially affected. The day to day terminal activities such as vessel loading / unloading, container handling etc. will cause additional underwater noise emissions. These are however not expected to be significant.

Road and rail noise depends on factors such as traffic intensity, the type and condition of the vehicles/trains plying on the road/railway line, acceleration/deceleration/gear changes by the vehicles depending on the level of congestion and smoothness of road surface. The baseline noise levels monitored at various locations along the candidate road indicate the baseline levels is exceeding the permissible limits for residential and rural areas and exceeds in some commercial areas. This is mainly because of the high density of road network and the traffic plying on them and towards sea the coastal wave actions also add up to the noise levels. Even the night, noise levels recorded at the various locations are close to or higher than the noise levels allowed during daytime.

This impact will be confined to receptors close to the road and rail. Both the construction and operation stage impacts can be effectively mitigated if the impacts have been assessed with reasonable accuracy in the design stage itself. During operation stage rise in noise level may arise due to increase in traffic. However, during this period noise pollution will be negligible, nevertheless a proper Environmental Management Plan (EMP) will be formulated for noise pollution.

5.1.1. Port operation

Operation of the port (container terminal, multi-purpose cargo, and cruise) does not include bulk or uncovered materials exported from or imported to the terminal or stored on site. The sources of air pollutants from port operations include combustion emissions from ships propulsion and auxiliary engines and boilers, mainly consisting of sulphur dioxide (SO_2), nitrogen oxides (NO_X), greenhouse gases (e.g. carbon dioxide [CO_2] and carbon monoxide [CO]), fine particulate matter [PM], and volatile organic compounds [VOC]), followed by combustion source emissions from vehicles, port equipment and land-based engines and boilers contributing similar pollutants. Volatile organic compounds (VOC) may also be emitted fuel storage and transfer.

However increased traffic on the access road has the potential to cause an impact on the air quality experienced by the residents along the access road; specifically an increase in pollutants such as oxides of nitrogen and particulates. Concentrations of primary pollutants generated by road traffic decrease exponentially with increasing distance from the road.

5.1.1.1. Ship Emissions

During the operational phase, there will be an increase in the movement of traffic and hence, emissions from the moving vehicles will also increase. The exhaust set at the port, the tugs, launches, diesel operated small boats, dredgers etc will enhance a pollution load during operational phase. With the increase in the number of ships and boats, their operation and movement of cargo to and fro will also increase. These activities will increase the pollution load in the atmosphere.

The Annex VI of MARPOL Convention deals with the "Regulations for the Prevention of Air Pollution from Ships". It sets limits on NOx and SOx emissions from ship exhausts, and prohibits deliberate emissions of ozone depleting substances. It also prohibits the incineration on board ships of certain products, such as contaminated packaging materials and polychlorinated biphenyls (PCBs). The vessels are required to comply with the regulations and should have the Prevention Certificate. Enayam port will take all appropriate measures to comply exhaust emission from vessels in accordance with MARPOL regulations and Emission standard norms so as to reduce pollution load in the air environment.

5.1.2. Mitigation Measures

The following measures could mitigate the anticipated negative impacts on the ambient air quality:

- Transportation vehicles to be properly and timely maintained and serviced regularly to control the emission of air pollutants in order to maintain the emissions of NO_X and SO_X within the limits established by international regulations;
- All static and mobile diesel-powered plant / generator sets should be used only during power cuts. Generators, machineries and vehicles are to be serviced and maintained regularly to avoid generation of dust and other air pollutants;
- Use of good quality fuel and lubricants will be promoted. Moreover, low sulphur content diesel shall be used as fuel for generator sets to control emission of SO_2 and regular verification of PUC certificates of all the vehicles entering into the port area. Vehicles older shall be equipped with leak detection systems.
- Include vegetation screens alongside the port access roads and apply of speed restrictions in order to the dispersion of pollutants from roads
- Water sprinkling will be carried out to suppress fugitive dust during earthworks and along unpaved sections of access roads.
- Environmental awareness program/training will be organised to the personnel involved in developmental works.
- Adequately sized construction yard will be provided at the site for storage of construction materials, equipment tools, earthmoving equipment, etc. In addition, temporary field offices and worker amenities will be provided at site. Appropriate spill control measures and labeling / handling procedures will be maintained.
- To reduce the impact on air quality, quarry material is planned to transport from respective quarries from nearby harbours to Enayam. This material transportation through sea will reduce dust as well gaseous emissions drastically.

Management of air quality at quarry site is important at all stages of the quarry cycle. The following measures are proposed:

- Blasting for quarrying shall only be carried out during calm wind conditions;
- A good blasting practice shall be adopted;
- Automated sprinkler system to be installed at quarry site to minimize the dust emissions;

- Quarry and construction materials shall be covered with sheets/enclosed during transportation and storage to avoid dust generation;
- Dust suppression techniques (e.g. wetting down, use of all-weather surfaces, use of agglomeration additives) for roads and work areas, optimisation of traffic patterns, and reduction of travel speeds;
- Exposed soils and other erodible materials should be re-vegetated or covered;
- New areas should be cleared and opened-up only when absolutely necessary;
- Loading, transfer, and discharge of materials should take place with a minimum height of fall, and be shielded against the wind, and consider use of dust suppression spray systems;
- Hardened roads should be laid in the area to avoid dust generation due to vehicular movement;
- Solid wood barriers or wind screen fabric should be used around the perimeter of construction site to avoid impact on neighbouring communities due to dust generated from construction activities;
- Dust suppression techniques (e.g. wetting down, use of agglomeration additives) for roads and work areas should be applied;
- Good maintenance of vehicles and equipment according to a periodical repair/revision programme;
- Use of good quality fuel and lubricants;
- Daily cleaning of access ways in the neighbourhood of work sites (removal of earth and sand) to prevent dust;
- Collection and temporary storage of sanitary and cleaning wastes, as well as garbage, in containers;
- Only Vehicles having Government license and PUC certificate for transportation of construction and quarry materials should be used;
- Energy conservation measures can enhance efficient energy consumption patterns and consequently affect the GHG emissions impacts in a positive manner.

If adequate measures such as sprinkling of water on haul roads around sites where clearance activities are on, covering material trucks especially those carrying sand and borrow materials etc, then the impacts can be reduced to a great extent. The main source of dust generation is due to site clearance activities, removal of trees and loading/unloading of construction material.

To mitigate the dust generation, following suitable mitigation measures shall be applied:

- Sprinkling of water shall be carried out.
- Asphalt plants, crushers will be sited at least 1.0 km in the down wind direction of human settlement and other sensitive receptors along the project corridor.
- During and after compaction of the sub grade/sub base water will be sprayed at regular interval in order to avoid dust generation.
- Vehicles carrying fine and coarse aggregate should be covered with tarpaulin in order to avoid the spills on the existing road.

Exhaust gas emissions are anticipated from construction plants, vehicles, etc. So in order to mitigate the exhaust gases, all the vehicles should be warranted with certificate proper maintenance of the vehicles shall be followed.

Operation of the port itself is not anticipated to result in any significant air quality impacts. The following measures could mitigate the anticipated negative impacts on the ambient air quality:

- Use electrical supply from the port main to the ship for all purposes for the entire period of stay in the port. This reduces pollution and also to reduce the diesel generated power consumption from the ship. Similarly most of the Cranes in the port will also use electric power.
- Transportation vehicles to be properly and timely maintained and serviced regularly to control the emission of air pollutants in order to maintain the emissions of PM, CO, NOx and SOx within the limits established by international regulations.
- All static and mobile diesel-powered plant / generator sets to be used only during power cut.
- Use of good quality fuel and lubricants to be promoted. Moreover, low sulphur content diesel to be used as fuel for generator sets to control emission of SO_2.
- Generators, machineries and vehicles are to be serviced and maintained regularly to avoid generation of dust and other air pollutants.
- Regular verification of .certificates of all the vehicles entering into the port area.
- Prohibition of use of old vehicles for construction and operational phase and use of electric cars inside the port area for all transport requirements.
- Developing air quality management procedures for ship operators, such as navigation of port access areas at partial power, achieving full power only after leaving the port area, limiting the practice of blowing soot from tubes or flues on steam boilers.
- Vegetation screens alongside the port access roads will be included and apply of speed restrictions in order to the dispersion of pollutants from roads.
- If the annual nitrogen dioxide concentrations exceed internationally accepted standards for protection of human health port operator have to consider resettlement of the residents living adjacent to the port access road.
- Although entire land area of port side is a green belt wherever possible thick greenbelt in port and its associated facilities will be provided.

5.1.2.1. Balance

Anticipated Impact	Mitigation Measures	
	Construction	**Operation**
Generate air pollutants like NO2, SO2, HC, CO, PM, VOCs,	Transportation vehicles to be properly and timely maintained and serviced regularly to control the emission of air pollutants. Static and mobile diesel-powered plant / generator sets should be used only during power cuts. Generators, machineries and vehicles are to be serviced and maintained regularly. Use of good quality fuel and lubricants will be promoted. Vegetation screens alongside the port access roads. Water sprinkling will be carried out to suppress fugitive dust during earthworks Environmental awareness program/training Adequately sized construction yard at the site for storage of construction materials Quarry material is planned to transport from respective quarries from nearby harbours to Enayam.	Use electrical supply from the port main to the ship for all purposes for the entire period of stay in the port. Transportation vehicles to be properly and timely. Maintained and serviced regularly to control the emission of air pollutants. All static and mobile diesel-powered plant / generator sets to be used only during power cut. Use of good quality fuel and lubricants to be promoted. Generators, machineries and vehicles are to be serviced and maintained regularly. Regular verification of certificates of all the vehicles entering into the port area. Prohibition of use of old vehicles and use of electric cars inside the port area for all transport requirements. Air quality management procedures for ship operators. Vegetation screens alongside the port access roads. Consider resettlement of the residents living adjacent to the port access road. Ambient air quality monitoring will be carried out regularly.

<table>
<tr><th rowspan="2">Anticipated Impact</th><th colspan="2">Mitigation Measures</th></tr>
<tr><th>Construction</th><th>Operation</th></tr>
<tr><td>Generation Particulate Matter, including breathable suspended particulate matter (dust generation)</td><td>Blasting for quarrying shall be carried out during calm wind conditions.

Good blasting practices.

Automated sprinkler system to be installed at quarry site.

Quarry and construction materials shall be covered with sheets/enclosed during transportation and storage.

Dust suppression techniques for roads and work areas, optimisation of traffic patterns, and reduction of travel speeds.

Vegetated or covered exposed soils and other erodible materials.

New areas should be cleared and opened-up only when absolutely necessary.

Loading, transfer, and discharge of materials should take place with a minimum height of fall, and be shielded against the wind, and consider use of dust suppression spray systems.

Hardened roads should be laid in the area.

Solid wood barriers or wind screen fabric should be used around the perimeter of construction site.

Dust suppression techniques (e.g. wetting down, use of agglomeration additives) for roads and work areas should be applied.

Only Vehicles having Government license and certificate for transportation of construction and quarry materials should be used.</td><td>Vegetation screens alongside the port access roads.

Greenbelt of adequate width should l be developed in all possible areas including Cargo storage areas and long the boundary of expansion project area.</td></tr>
</table>

Table 47 Enayam Alternative. Predicted Project Impacts on Air Qualities and Mitigation Measures

5.1.2.2. Mitigation measures for Noise Pollution

The following measures could mitigate the negative impacts caused by noise emissions:

- Noise mitigation measures shall be in place prior to the commencement of any construction work.
- All contractors and subcontractors involved in the port construction phase should comply with the relevant international noise standards.
- Activities that take place near residential or sensitive receptors to be careful planned (restricted to daytime, taking into account weather conditions, etc.).
- Residents in the vicinity to be notified about construction schedules and activities;
- All plant and equipment to be fitted with silencers, mufflers, acoustic linings, or shields, as necessary.
- If necessary, measures to be taken to reduce noise emissions from the site shall include provision of screens or bunds to absorb noise and deflect it away from receptors.;

- Before commencing any piling operations, the contractors shall be required to submit calculations to demonstrate that the appropriate standards will not be exceeded.
- Timing and programming outside sensitive seasons especially concerning underwater noise.
- Apply a change management process to modify operations, if necessary to address noise issues.
- Vehicles and generator sets to be serviced regularly and maintained properly to avoid any unwanted generation of noise or vibration from them.
- Employees working in noisy environment should be made to wear ear muffs/ear plugs to avoid any adverse impact of noise on them.
- Employees exposed to hand vibration while handling/operating of heavy machineries should compulsorily wear anti vibration gloves made up of visco elastic material.
- Shock absorbing techniques should be used to minimise the impact of vibration from heavy machineries. Heavy machineries and generators to be operated during day time only.
- A noise monitoring programme during construction should be implemented
- Preferably battery operated very low noise generating vehicles will be used in the port premises during operational stage
- Optimising dredging activity and duration.

The noise generated from construction activities of road and rail corridors is temporary and cease upon completion of construction phase.

- Contractor should adhere to good machineries and must take all precautions to control noise pollution.
- The Diesel Generator sets should be erected with good enclosures for controlling noise.
- A regular noise monitoring programme should be defined and implemented for the port.

Considering the very low traffic growth scenario noise barriers are not required in any of the locations along the Road as well as the rail corridor. However in case after several years if this is found necessary then following are the mitigation measures suggested:

- Requirement of noise barrier wall, minimum height of 2.5 m can be constructed on either side of the rail corridor where ever found necessary. During the design of elevated structures, wind load need to be considered for computing the height of noise barrier wall.
- Proper maintenance of the rail track and rail wagon, by frequent lubrication to avoid frictional noise.
- Allowing the rail to travel with an optimum speed.
- Noise barrier for the road where the settlements/cluster of houses (or Silence zones) will be present.
- No solid noise barriers are found necessary due to very low traffic expecting for the first years. During this period of low traffic, only strip plantations (also called Green noise barrier) will be planted. In a green noise barrier the individual leaves will act as noise attenuators. The smaller the size of the leaves, the better the attenuation. Similarly, the more the number of these small leaves, the better the noise attenuation.

5.1.2.3. Balance

Anticipated Impact	Mitigation Measures	
	Construction	Operation
Noise	All contractors and subcontractors should comply with the relevant international noise standards. Activities near residential or sensitive receptors to be careful planned (restricted to daytime, taking into account weather conditions, etc.). To be notified about construction schedules and activities. Plant and equipment to be fitted with silencers, mufflers, acoustic linings or shields. Screens or bunds to absorb noise. Programming outside sensitive seasons especially concerning underwater noise. Apply a change management process to modify operations, if necessary to address noise issues. Vehicles and generator sets to be serviced regularly and maintained properly. Employees working in noisy environment should be made to wear ear muffs/ear plugs to avoid any adverse impact of noise on them. Employees exposed to hand vibration while handling/operating of heavy machineries should compulsorily wear anti vibration gloves made up of visco elastic material. Heavy machineries and generators to be operated during day time only. Blasting for quarrying shall only be carried out during calm wind conditions (November to May). A good blasting practice with specific blasting plans shall be adopted. In quarrying site shall be carried out during day time only. Laborers working near the blasting area shall be provided with ear muffs. Optimising dredging activity and duration A noise monitoring programme should be implemented.	Battery operated very low noise generating vehicles will be used in the port premises during operational stage. Residents along the access road might be offered relocation or compensation. Acoustic fencing might be installed along the edge of the access road should the traffic-generated noise levels be significant. Vehicles and generator sets to be serviced regularly and maintained properly. Employees working in noisy environment should be made to wear ear muffs/ear plugs to avoid any adverse impact of noise on them. Regular noise monitoring programme should be defined and implemented. Noise barrier wall, can be constructed on either side of the rail corridor where ever found necessary. Proper maintenance of the rail track and rail wagon, by frequent lubrication to avoid frictional noise. The rail to travel with an optimum speed. Noise barrier for the road where the settlements/cluster of houses (or Silence zones) will be present. Strip plantations (Green noise barrier) will be planted.

Table 48 Enayam Alternative Predicted Project Impacts on Noise Pollution and Mitigation Measures

5.1.3. Land resources. Coastline/Shoreline

During construction phase, changes in land use and land cover may arise, and topography will be changed. Due to construction activity and Soil compaction, consolidation may cause in loss of vegetation and tree cover, soil pollution and even flooding also.

Significant amount of construction material will be required, particularly quarry stone for the construction of breakwater, bunds, buildings, etc. This will be obtained generally by excavating from the quarry sites. It is imperative that these sites be treated/closed/isolated, once the excavation of construction material is completed. The ideal measure for treatment is the refilling of these sites to its original level and their re-vegetation.

The viable option for rock quarrying and transportation which is socially acceptable, environmentally sound and technically feasible is transportation of rocks to the site through barges. The potential quarry areas have been located near Colachel area.

5.1.3.1. Changes in Coastline/Shoreline

Coastal structure similar to a groin or a breakwater when introduced into the sea interrupts wave induced littoral sediment transport in the direction of flow. The obstruction of sediment transport leads to sediment built-up up-drift and erosion down-drift due to deficit in sediment supply due to the obstruction. The coastal geomorphology of the Enayam coastal area consists of the small beaches, rocky coasts, headlands, bays and low cliffs. Habitats and establishments in the close proximity to the shoreline are noticed in the areas adjacent to the proposed port.

The Assessment of shoreline change will be based on the data acquired by means of Indian Remote Sensing Satellite (IRS) and Landsat Thematic Mapper (TM)/Enhanced Thematic Mapper (ETM). It will be made by comparing historical maps and charts provided based on accurate surveys. Remote Sensing and GIS techniques could be effectively used for the assessment of shoreline changes. Other approaches (Satellite imageries, Google images, one dimensional and two dimensional numerical models and Survey of India maps) will be used to study the shoreline changes along the coast.

During operation phase, soil pollution may happen if solid and liquid waste not managed properly. Flooding may happen if drains are not properly maintained.

5.1.3.2. Discharges from Ships on Land

No discharge of wastewater/waste from the ships calling at Enayam port will be permitted into the port area. Facilities for discharge of waste oil will be provided at the port. The ships will have their own sewage reception/treatment facilities on board and hence no discharge of sewage will be done at the port. In addition, the ships are expected to discharge sewage in deep seas as per defined procedures for International ship movements.

This will ensure the ships have their own storage capacities in their on board sewage receptions to handle wastes generated during the period/days the ship is at the port. Each ship shall have on board a ballast water record book which may be an electronic recording system. Port officers may inspect the ballast water record book.

5.1.3.3. Mitigation Measures

The following measures will be implemented to minimize adverse impacts on environment during quarrying:

- Quarrying will be done from approved/legitimate quarries to minimize impacts. Quarry operations will be restricted to daytime to reduce the impacts from increased noise and will be minimized to reach the threshold levels stipulated at the nearest habitations.
- It will be ensured that quarry sites and borrow pits be of a regular shape and if possible, of equal size. If possible, their location would be at least 1.5 km away from the nearest habitation.
- Runoff water collected in the lowest pits will be drained in to the nearest water body by a drainage system.
- Only rocky outcrops will be quarried and quarrying below the general ground level, surrounding the rock will be avoided.
- Some localized road improvement measures will need to be undertaken near the quarries and near the project site to enable moving of the large quantity of stones by road using trucks.
- Quarry management plan will be prepared and approved with the help of super vision consultants in place before excavation started.
- The roads which will be used for rock material transport will be widened and strengthened.
- To mitigate impacts from transportation of construction material, existing roads will be strengthened wherever necessary.
- Temporary approach roads may be developed with prior permission from competent authority.
- Trucks with construction material susceptible for fugitive suspension will be covered with tarpaulin covers.
- Transportation management will be adopted for movement of dumpers transporting quarry stones and construction materials and traffic will be regulated.
- Vehicles deployed will conform to emission norms (air/noise) and have valid Pollution Under Control certificates
- Dumpers and trucks will comply with standards for exhaust emissions and noise levels.
- Worker camps will be adequately equipped with necessary facilities such as water supply, power supply, wastewater collection, solid waste collection and sanitation, fuel supply, etc.
- Domestic wastes generated from worker camps will be collected properly treated and disposed after complying with the norms stipulated by statutory authorities.
- No bore-wells will be driven to meet the water requirements to avoid impacts on groundwater resources.
- All these will be part of the Quarry Management Plan to be prepared and approved with the help of the supervision of consultants.

Judicial planning of port facility will be carried out. Reclamation bunds and setting ponds shall be constructed, the dredged material will be pumped into the reclamation area enclosed by reclamation bunds wherein the solids will be allowed to settle and the return water will be directed into sea through appropriate return channel/pipelines. The dredge fill will be covered by gravel before hard standing. After completion of the reclamation and hard standing, necessary development shall be carried out.

- In order to prevent the seepage of return sea water into the groundwater, suitable impervious liners will be provided all along the return water channel if required. Also minimum required retention time of return water in the reclamation area as well as in the return channel will be ensured.
- In order to study variations in groundwater quality of nearby villages due to reclamation, regular water quality monitoring will be carried out.

- Continuous monitoring of shoreline with the help of high resolution satellite imageries.
- Fixing of shoreline just prior to construction phase by latest satellite imagery and then ground truthing on a regular basis with close monitoring and ground markings.
- Efforts will be made to aggressively monitor the highly eroding areas. Dredging of the area to be accreted shall be carried out regularly and the material shall be used for maintaining the eroding coastal stretch, if observed. The excess/unusable material shall be disposed at the identified offshore disposal location.
- An intensive monitoring oriented Shoreline Impact management Plan will be in place prior to construction and operational phases. This activity will be entrusted to a competent.

5.1.3.4. Balance

Anticipated Impact	Mitigation Measures	
	Construction	Operation
Changes Land Use	The land use of the backup areas may not be changed. The facilities and other building will be constructed as per the existing landscape without any major cutting and filling. The planning will to minimize major landscape changes. Land reclamation and change in land use pattern will be limited to the proposed port limits and will be carried out in such a way that to ensure the proper drainage. Seepage of return sea water into the groundwater, suitable impervious liners will be provided all along the return water channel. The entire strip road will be transformed to port owned transportation land. This will be generally available for the public use. No bore-wells will be driven to meet the water requirements to avoid impacts on groundwater resources.	Runoff water collected in the lowest pits will be drained in to the nearest water body by a drainage system.
Changes Coastline/Shoreline	Fixing of shoreline just prior to construction phase by latest satellite imagery. Reuse the material of dredging in the port.	Continuous monitoring of shoreline with the help of high resolution satellite imageries. Monitoring the highly eroding areas. The excess/unusable material shall be disposed at the identified offshore disposal location. An intensive monitoring oriented Shoreline Impact management Plan will be made.

Table 49 Enayam Alternative .Predicted Project Impacts on Land Environment and Mitigation Measures

5.2. WATER ENVIRONMENT

5.2.1. Capital dredging and disposal

Dredging removes bottom biota and dumping of dredged material covers bottom habitat.
Marine water quality will be impacted due to dredging and disposal and also during construction of breakwaters and cargo berths during construction phase. Direct impact of these activities on marine water quality would be an increased turbidity due to suspended sediment and will be predominant during dredging.

However the seabeds off the coast of Kanyakumari that may be affected, are mainly made of sandy or rocky without areas of special ecological importance, there are no corals or sea grass patches, moreover strong currents and tides mobilize significantly sediments and sands . This makes no major impacts occur by altering the bed or by increasing water turbidity .

Turbidity due to dredging operation varies with depth and lateral distance from the dredger location. During dredging, transport of sediment depends on velocity and fine material concentration. Very fine cohesive material will remain in suspension for a long time and is independent of hydrodynamic conditions. Due to above factors, there will be an increase in turbidity due to suspended sediment in water column. Thus, it can be inferred that dredging can cause a short-term and localized impact on marine water quality.

Impacts related to the ocean disposal of dredged material are confined mainly to temporary water column impacts and longer term benthic impacts. The disposal of fine dredged materials at sea will cause turbidity in the water column and settlement of the material over deep-water benthic communities. This is not likely to be significant at great depth since the sediments are fine grained and will therefore become quickly and widely dispersed and there is less to be impacted at greater depth. The potential severity of the impact would be dependent on the location of the disposal site relative to valuable shallow water ecosystems (e.g. coral reefs, sea grass fields).

5.2.1. Impact on Ecology due to Reclamation

The proposed Port is to be developed mainly on reclaimed land. Apart from turbidity, the marine water quality could be affected due to aqueous discharge (oily wastes, sanitary wastes, etc.) from the dredgers, barges and workboats involved in the activities.
Control de maquinaria y equipos u plan de emergencia en fugas de sustancias contaminantes al mar.

The construction of marine structures such as breakwaters will change the current patterns and results in tranquil conditions suitable for the operation of the port.

In case, the untreated wastewater from the domestic/industrial activities in the vicinity of the port flows into the harbour, it can result in stagnation of water. This condition may deteriorate harbour water quality through increase of phytoplankton and a decrease of dissolved oxygen, resulting from eutrophication of water, caused by effluents containing nutrient salts (chemical compounds including N and P). Anaerobic water leads to the generation of hydrogen sulphide (H_2S).

Also during the construction there will be a large increase in water demand. This demand will be determined by the needs in the proceedings of execution of works and the increase of people in the harbor.A preliminary assessment indicates that daily demand for potable water will be around 0.1 MLD in the construction phase.

Most important prevailing issue of the Enayam Urban Area is scarcity of water not only for drinking but also for meeting other domestic (bathing, washing, etc.) requirements. The urban areas are frequently over exploited.

One of the main reasons for this is the hard rock terrain wherein there is less water availability (both surface and groundwater). A special study will be carry out to understand the hydrology. This provides a very general idea about the water availability in the region and could collate lot of data already available for this region.

Due to several intrusive rocks and other hard rock and recent rock formations the geology and hydrogeological aspects need to be studied very closely to ascertain the water resources especially groundwater.

Water requirement will be minimum for proposed road construction, the entire length of the road is less as possible. The peak water requirement for construction phase for roads could be a maximum of 10 m^3/day.

There are a number of activities associated with construction of the proposed project, which could have impacts on surface water:

- Contamination of surface water sources if wastes and wastewater from labour camp not managed properly.
- Pollution of surface water caused by improper handling and disposal of other types of construction site wastewater.
- Blockage of the small natural streams by the reclamation or otherwise by solid structures may lead to ponding in the area behind the port. The design should therefore cater for a free flow of the discharge water, even in the wet season.
- Surface water regimens may be altered because of potential changes to the drainage pattern. Water pollution may result from wastewater produced by the quarry activities and by the accidental spillage of fuel, lubricants and other chemicals used in the quarry process.
- Poor control of run-off from site activities leading to siltation and eventual blocking of drains caused by excessive sand and silt in the storm water run-off.

Also a number of activities associated with construction of the proposed project could have an impact on groundwater:

- Spillage or infiltration of oils, fuels and hydraulic fluids from plant maintenance areas into the soil.
- Blockage of natural drains in the port area will lead to higher groundwater tables and a permanently changed drainage pattern.
- New drainage structures due to the quarry activities might affect groundwater levels and quality.
- Where blasting is used in quarry, there is a potential for infiltration of nitrate and ammonia residues, in groundwater. This should be managed through appropriate blasting design and procedures, including ensuring the correct burning of explosives.

5.2.2. Impacts During operation

The proposed port is container and multipurpose port, there will be no dusty cargo, dry bulk cargo such as coal, iron ore or hazardous cargo, etc. will be handled at port. Hence, direct impact on water with cargo handling will be insignificant.

Marine water may get polluted as a result of releases of contaminants, if any into the marine system including.

If the natural streams in the port area will be kept and discharge continues in the port, port water quality will be adversely affected on a permanent basis, even more than at present since the discharge water will be contained by the breakwater.

The leakage/ spill of oil in port and its surrounded area will be impact water quality.
The operational port with its entire infrastructure is going to build further pressure on the already depleted water resources due to the tourists and other port staff and traders dependency.

Roads. The ponds and rivers could be impacted by solid waste disposal from the travellers. Travellers/tourists people have the habit of throwing waste material carelessly to water bodies. This is more important because the road users could be not only from various part of the country but also from all over the world

Rail. The only major planned cargo transport is containers. Other than the bunkering of fuel for the port requirements no major hazardous cargo or liquid terminal is planned for this port. Therefore no spillages are expected from either the incoming or outgoing container traffic.

5.2.3. Mitigation Measures

5.2.3.1. Mitigation Measures during Reclamation.

- While reclaiming the area, bunds will be provided with a suitable overflow facilities so that only clear water will be returned to the sea. Ecology in the vicinity of the Port is not anticipated to be disturbed during reclamation.
- Return seawater quality from the reclaimed area shall be monitored during reclamation phase. Groundwater quality of nearby villages (Enayam) needs to be monitored during construction phase.
- An adequate drainage system will 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 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.
- The port Water Management Plan should be developed in order to secure the project sustainable water balance and in the project region in the construction phase, including as main water source the Thamirapani river and other artificial water sources in use as of today.
- A surface water monitoring program shall be implemented during the construction phase. Effective water conservation measure should be followed:
- Implementation of rain water harvesting/ storm water management in the projection region.
- Regular monitoring of surface water for quality and quantity water needs should be limited through recirculation and reuse, implementing closed-circuit systems from sedimentation ponds to the quarrying process.
- Storm water should be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.
- Providing water & wastewater treatment facilities at construction camp.
- A ground water monitoring program shall be implemented during the construction phase. .A study should be initiated to investigate the change in hydro-geological conditions, the available aquifers and safe yield levels. The phreatic aquifer should not be affected when aquifers are exploited.
- There can be rainwater harvesting and large borehole diameter where existing women bathing or washing purely for boosting domestic requirements

Acute water scarcity is an important issue for the local people, the project need to address the issue to the extent possible by including it in Corporate Social Responsibility

Working with several satellite imageries the Lineament map would be prepare over exploited area. Lineaments are subsurface fracture zones which are usually good aquifers due to the several kilometres of linear connection to fractures in hard rock area. Most of these lineaments are identified as potential groundwater zones.

Apart from siltation of water bodies and natural streams with sediments, during construction phase water pollution could be there. Part of the water resources will have to be filled to accommodate the planned road alignment. Is necessary to found the best to avoid impacts to the water resources or the settlements.

The water requirement for construction of the proposed rail alignment (including for the structures) if abstracted from local resources during dry season could lead to drying up of the local drinking water sources of the area.

One of the most important impacts along the road stretch is the impact to water bodies. The construction activities including excavations could lead to subsurface disturbance to the aquifer geometry and could lead to seepage or drying up of ponds:

- Water ponds can be bridged with suitable structures at ground level to avoid plugging of springs and connectivity to the phreatic aquifer (e.g. use of a gabion structure may be evaluated).
- A hydrological study of the area surrounding the ponds should be conducted to know more about the aquifer conditions in the area.
- Compensation to the reconstruction of the pond with an equal area of pond by digging or excavating on the side of the proposed road alignment or increase the embankment height in all directions.
- Most important mitigation measure is avoidance of impacts by changing the alignment or planned activity.
- Consultation meeting will be held with all stakeholders that include institutions and local public.
- Streams in port area which are connecting sea will be treated in upstream side of the stream.
- Treated water will be discharged into sea water after meeting marine discharge standards prescribed by MoEF.
- Port operators should prepare a Spill prevention, control, and counter measure plan consistent with the IMO Manual on Oil Pollution Section II – Contingency Planning.
- All ship related waste with a potential to cause pollution to the marine environment should be disposed of according to the guidelines stipulated by the MARPOL Convention.
- Port authorities will apply appropriate procedures, in agreement with National and international regulations, for the handling and storage of hazardous cargoes and waste generated by handling and storage of this type of cargoes.
- Ships used for the project should be registered and will comply with all international maritime conventions.
- Good operational practices will be doing such as good positioning and protection of fuel stores, use of drip trays, proper maintenance of plant and equipment.
- Careful storage and usage of fuels, oils and chemicals. Consider whether fuel storage is needed on-site, how much is to be stored and how. All companies, included sub-contractors will have adequate fuel storage facilities.
- Fuel and oil stores must be located away from the site drainage system and the shoreline. If this is not possible, will ensure adequate measures are identified to prevent or contain any spillage.

- Oil and chemical-handling facilities will be located with consideration of natural drainage systems and environmentally-sensitive areas
- Hazardous materials storage and handling facilities will be constructed away from active traffic and will protect storage areas from vehicle accidents
- Fuel dispensing equipment will be equipped with breakway. Those connections that provide emergency shutdown of flow should the fuelling connection be broken by movement.
- All ancillary equipment (e.g., valves, hoses) should be contained securely within the lock when not in use. Will ensure that tanks are correctly marked or labeled as to their contents and capacities
- Keep a store of spill response equipment at the fuel facility and bowsers.
- Standard operating procedures that reduce or eliminate the chance of a spill, even in the case of equipment failure.
- Routine maintenance and testing schedules should be determined for all aspects of port operation particular attention paid to product storage and handling and fuel transfer systems.
- General awareness of all workers should be increased through training and safety meetings with focus of Environmental Management systems and practices with "Zero Waste Tolerance" planned with an objective to achieve as much as we can.
- Port operator should be required to develop system for holding and collecting storm water runoff and surface runoff produced by site activities and its treatment before discharge.
- Waste water should be treated up to the standards for discharge (Prevention and Control of Pollution).

As for Road & Rail Connectivity

- In order to avoid the littering of waste material into the water bodies; it is recommended to put out of sight the exposure of the water bodies from the road user by constructing a protective wall along the sides of the bridges / culverts. In addition to the proposed function, the protective side wall will also serve as noise barrier.
- Walls and slabs is proposed to prevent seepage at ponds. This will arrest any possibility of drying up of the water in the pond.

5.2.3.2. Marine water quality

- The wastewater and sewage generated during construction at site and at labour camp will be collected in holding tank and periodically transferred to nearby Sewage Treatment Plant (STP). In case of non availability of nearby STP, septic tank with soak pits is recommended during construction phase.
- Surface run-off from the construction site should be discharged via sand/silt removal facilities such as sand or silt traps and sediment basins. Channels, earth bunds, or sandbag barriers should be provided on site to direct storm water to such silt removal facilities.
- Waste water management plan will be incorporated in the contractors EMP. Special provision will be made to select Contractor with proven track record in implementation of EMP. Payment provision shall be linked to the successful planning and implementation of EMP including good Contractor and labour camp will all EMP facilities.
- Breakwaters shall be constructed in a way to maintain good tranquil conditions.

Often used to limit the impact of turbidity. In some cases where relatively quiescent current conditions (0.2 ft/sec or less) are present, turbidity levels in the water column outside the curtain can be 80 to 90 percent lower than the levels inside or upstream of the curtain. While there may be a turbid layer flowing under the curtain, the amount of suspended material in the upper part of the water column, as a whole, is substantially reduced.

However, the effectiveness of turbidity barriers can be significantly ·reduced in high energy regimes characterised by currents and turbulence.

With respect to overall effectiveness and deployment considerations a current velocity of approximately 1.5 ft/sec appears to be a practical limiting condition for turbidity curtain use.

To determine if guidelines have been exceeded during dredging, ideally, for long-term exposures, initially, measurements should be taken every six daytime hours during initial operations (no more than 10 days), less frequent monitoring may commence once the likely levels of turbidity during operations have been established and found to be within the guidelines. Measurements can then be taken on a gradually less frequent period though never to be less than once daily during operations.

A possible proposed disposal site location is in deep water where prevailing currents will not bring the settling material back inshore. The above is not to suggest that the deepwater benthos does not contain valuable biological resources but these are, presumably, not as vulnerable to diffused sedimentation as would be shallow water coastal ecosystems.

The Colachel (Enayam alternative) Port administration have to prepare a Dredge & reclamation Management Plan to avoid and control anticipated impacts.

5.2.3.3. Balance

Anticipated Impact	Mitigation Measures	
	Construction	Operation
Contamination / pollution of surface water sources	Implementation of rain water harvesting/ storm water management. Recirculation and reuse, implementing closed-circuit systems. Water & wastewater treatment facilities at construction camp.	Streams in port area which are connecting sea will be treated in upstream side of the stream. Appropriate procedures, in agreement with National and international regulations, for the handling and storage of hazardous cargoes and waste generated by handling and storage of this type of cargoes. Put out of sight the exposure of the water bodies from the road user by constructing a protective wall along the sides of the bridges / culverts.
Alteration surface water regimens .	Storm water should be separated from process and sanitary wastewater streams. Water ponds and rivers can be bridged with suitable structures at ground level Reconstruction of the pond with an equal area of pond by digging or excavating on the side of the proposed road alignment or increase the embankment height in all directions. Avoidance of impacts by changing the alignment or planned activity	Walls and slabs is proposed to prevent seepage at ponds. This will arrest any possibility of drying up of the water in the pond.

Anticipated Impact	Mitigation Measures	
	Construction	Operation
Siltation and eventual blocking of drains caused by excessive sand and silt in the storm water run-off.	Sedimentation ponds to the quarrying process. Surface run-off from the construction site should be discharged via sand/silt removal facilities such as sand or silt traps and sediment basins.	
Contamination / pollution or modification of ground water sources	Study to investigate the change in hydro-geological conditions, the available aquifers and safe yield levels. The phreatic aquifer should not be affected when aquifers are exploited. There can be rainwater harvesting and large borehole diameter where existing people bathing or washing purely.	Waste water should be treated up to the standards for discharge (Prevention and Control of Pollution). Implementation a water quality monitoring programme. Port operator should be required to develop system for holding and collecting storm water runoff and surface runoff produced by site activities and its treatment before discharge
Changes marine water qualities	The wastewater and sewage generated at site and at labour camp will be collected in holding tank and periodically transferred to nearby Sewage Treatment Plant . In case of non availability of nearby STP, septic tank with soak pits is recommended during construction phase. Waste water management plan will be incorporated in the EMP. Breakwaters shall be constructed in a way to maintain good tranquil conditions.	Treated water will be discharged into sea water after meeting marine discharge standards prescribed by MoEF Port operators should prepare a Spill prevention, control, and counter measure plan consistent with the IMO Manual on Oil Pollution Section II – Contingency Planning. All ship related waste with a potential to cause pollution to the marine environment should be disposed of according to the guidelines stipulated by the MARPOL Convention. Ships used for the project should be registered and will comply with all international maritime conventions. Oil and chemical-handling facilities will be located with consideration of natural drainage systems and environmentally-sensitive areas. Fuel dispensing equipment will be equipped with breakway. Those connections that provide emergency shutdown of flow should the fuelling connection be broken by movement.

Table 50 Enayam Alternative Predicted Project Impacts on Water Environment and Mitigation Measures

5.3. SOLID WASTE MANAGEMENT

5.3.1. Potential impact due to contruction

Construction will potentially generate the following wastes: green wastes from vegetation clearance, excess construction materials, including offcuts and packaging; hazardous wastes; oils, fuels and other chemicals generated by onsite maintenance and repair of construction equipment and machinery.

Excavation materials; food wastes from construction personnel; site office wastes; and human waste; poor construction procedures that generate excessive wastes increase construction costs and results in disposal of otherwise valuable resources. In the study area no sanitary landfill is foreseen. Therefore, there is a moderate risk to the soil quality, surface and groundwater and marine environment.

5.3.1.1. Hazardous Materials Management

Hazardous wastes (oil, chemicals, lubricants, paints, compressed gases, and varnishes, etc.) generated during the construction phase should be dealt with separately from non-hazardous waste.

5.3.1.2. Quarrying

Among others, solid waste will result from the clearing of trees and bush, from rock waste and removed topsoil. Other waste might originate from the destruction of structures, or from garbage dumped along the road and from household wastes from the construction workers. Rock impurities and trace components might cause hazardous wastes and should be managed appropriately.

5.3.1.3. Dredging and Reclamation

Most of the dredge spoil will be used for the reclamation, some spoil generated needs to be disposed-off, and sediment contamination could happen.

5.3.1.4. Impacts due to Road/Rail Corridor Development

The issue of solid waste like water scarcity is a prevailing environmental issue of the Enayam-Colachel area. Solid waste from the road and rail corridors during construction will be mainly domestic scraps and wastes from the construction camps and construction spoils from construction sites.

5.3.1.5. Mitigation Measures

The port Waste Management Plan for construction and operation phase should be developed definingadequate measures for waste collection, segregation, reuse and disposal.

The sewage/solid waste/hazardous wastes to be treated and disposed or sold to authorised recyclers as per the MoEF guidelines.

- Port operator should prepare a Waste Management Plan defining adequate measures for Waste collection, segregation, reuse and disposal during construction.
- Proper sanitation bins to be installed in the port area for collection of sewage/solid waste/construction wastes on site.
- Solid waste generated during the construction process to be separated and recycled where possible / appropriate.
- Burning of waste on site should not be permitted. All waste, which cannot be recycled on site, should be collected and taken off site for recycling/reuse or disposal to an official/municipal waste disposal site after consultation with local authorities.
- A „scavenging boat" should be available at all times for collection of windblown rubbish within the harbor basin itself.
- All rubbish, waste materials and debris shall be systematically cleared from working areas as they accumulate; all such materials should be cleared at the end of each working day.
- If removal of waste materials at the end of the working day is not possible, the materials should be covered with tarpaulin or similar.
- Waste materials not removed directly from the site shall be temporarily stored at designated points and covered, pending removal from the site.

- All working areas and site roads to be kept clear of mud, water, silt and other materials at all times. If earth, mud, or other debris is deposited on roads, it shall be immediately removed.
- Small amount of construction debris will be disposed of in suitable pre-identified dumping areas in tune with the local condition to avoid land degradation and water logging due to indiscriminate dumping.
- Dumping areas shall be covered with topsoil and subsequently plantation shall be done over them
- Regular inspection of haul roads, construction site shall be carried out to ensure regular and timely removal of construction debris to the dumping site.
- Hazardous waste should only be handled by legitimate enterprises and following good international practices and applicable local and international regulations (Bazel and Rotterdam Convention)

5.3.2. Solid waste-impact due to port operation

The amount of solid waste produced by the operational activities in the proposed port may be quite substantial. Wastes originating at the port may include inert solid waste from cargo packaging and from administrative offices, as well as hazardous or potentially hazardous waste associated with vehicle and equipment maintenance operations (e.g. used lubricating oils and engine degreasing solvents). Wastes originating from ships may include oily sludge, inert materials such as food packaging, and food waste. Among others, substantial amounts of solid waste will result from the terminals" daily and periodic activities, including the cleaning of storage tanks.

The quantity of municipal solid waste generated from canteen and administrative areas is estimated at about 1 MT /Day, of which 60% will be bio-degradable and 40% non-biodegradable. These wastes will generate odour and health impacts and ground and surface water contamination, if not managed properly.

5.3.2.1. Solid Waste due to Road/Rail Corridor Development

The solid waste mainly comes from the road users. They might throw all the unwanted materials present with them like plastic bags, water bottles and some other materials, etc., while passing through the road. Such materials get accumulated on the road or may lie along roadside which can obstruct the easy movement of vehicles sometimes.

No solid waste is expected / generated along the proposed rail alignment as this is specifically dedicated corridor for port container cargo only. No passenger traffic is expected along the alignment.

5.3.2.2. Mitigation Measures

The port Waste Management Plan should be developed defining adequate measures for SW collection, segregation, reuse and disposal. Port operation activities solid waste shall be adequately collected and managed by Contractor (as one option) in accordance with the relevant Indian laws, IFC PSs and IFC EHS guidelines for Waste Management Facilities.

In accordance with the requirements of MARPOL 73 /78 and its annexes IV and V, appropriate facilities shall be provided for the reception of all wastes arising from ships. These should include facilities for the following basic categories of ship-generated wastes:

- Oily waste (usually oil mixed with larger quantities of seawater, also fuel residues and sludge).
- Garbage (originating from crew and passengers, maintenance of the ship, cargo and fishing activities).

Dustbins shall be provided along roadside so that the road users can use them for disposal of waste materials if any. Signboards can be installed at desired locations along the roadside propagating people about the environment to keep neat and clean.

5.3.2.3. Balance

Activity	Anticipated Impact	Mitigation Measures
Construction activities, workers camp and operation of terminals	Increase in solid waste generation and increased pressure on existing disposal sites Reduced availability of drinking water on account of increased pressure on existing drinking water supply scheme	A separate workers camp shall be established by the project developer, in which basic facilities like drinking water, sanitation facilities and sewage/solid waste management for the workers/employees of the port shall be provided. Cooking fuel will also need to be provided for by the contractor to the workers in the camp to avoid destruction of local green cover. Project shall have its own STP for treating wastewater generated in labour camps and other processes.
		Primary health care and basic first aid shall be provided at construction site / labour camps. Key requirements are: (i) availability of adequate number of properly stocked first aid kits (wrapped sterile adhesive dressings, individually wrapped eye pads, individually wrapped sterile wound dressings of various sizes, triangular bandages, safety pins and sterile gloves); and (ii) first aid training of staff and workers.

Table 51 Enayam Alternative Waste Management. Anticipated Impact and Mitigation Measures

5.4. SOCIO-ECONOMIC IMPACTS

It is expected that the construction and operation of the Colachel Port and associated installations, will have both positive and negative socio-economic impacts on the neighbouring communities and the region as a whole. Nevertheless, from a social point of view the expected positive impacts, i.e. benefits, will by far exceed the expected negative ones.

The following chapter summarizes the key socio-economic and socio-cultural issues relating to the project

The activities will take place during the construction phase of the proposed project are the following

- Transportation of quarry materials. The impact will be caused by quarrying and
- Transportation of quarry materials.
- Dredging and Reclamation.
- Construction of the breakwater and terminals.
- Road & rail construction.
- Establishment of labour camps

Activities will take place during the operations phase of the proposed project are the followint

- Operation of terminals and the Port itself.
- Changes in marine traffic.
- Maintenance dredging.
- Changes in traffic due to Port operations (loading/uploading of cargo, etc.).

5.4.1. Impacts on the population

5.4.1.1. Employment and income levels

The proposed Colachel-Enayam Port Project promised many far reaching indirect benefits for the local communities, including: employment opportunities. During the construction phase the dam and the associated infrastructure is likely to phenomenally increase job opportunities – particularly to the many idle youth in the area.

Especially for the first time, many unskilled people in the area, will have a rare opportunity (offered on a large scale), to be engaged in wage employment right in the village. Regarding raise on incomes rates, wages earned by the local workers from the construction activity will circulate in the local economy – this resulting in greater investments in productive endeavors and hence, contributing significantly to the growth of the local economy. Taking into account that, the project t may take up to 30 months to complete, the construction activity and the linkages it will create, will give rise to increased demand for the supply of the locally produced goods and services.

During the construction phase of the Port and the associated infrastructures, the project is likely to phenomenally increase job opportunities. In the operational phase, due to the envisaged emergence of vibrant centers of commerce around the Project sites, it is expected that in the long term, availability of job opportunities for the local people, will be sustained in the various sectors of the local economy.

Higher impact on local employment will come from a higher unskilled labor demand, although they can become skilled laborers during their large experience over the construction period, . fishermen might have a chance to acquire new skills, and increase commercial activity during the construction and operation of the Port In the way that a higher technical complexity will demand a higher proportion of skilled labor, this factor plays a negative role for local employment.

Project construction will create employment opportunity and leads to increases in income of the surrounding community. Workers in these camps create demand and therefore market for food and other services. These camps also require sanitation, which in most cases involve pit latrines. If care is not taken, there is danger of seepage and contamination of ground water resources and water courses, where the latrines are sited near these. The roof catchment of the camp buildings can also cause further soil erosion.

The construction activity – during the construction phase, will ensure that the many local people employed, are paid wages – this greatly enhancing direct income earning capacities for the communities, who would have otherwise relied only on low income-earning fishing and agriculture. Wages earned by the local people working in the construction activities will circulate in the local economy – this resulting in greater investments in productive endeavours and hence, contributing significantly to the growth of the local economy.

Indirectly therefore, the Project will contribute greatly to the rise in the income levels of the local communities – and hence to poverty reduction. During the operational stage, the envisaged development of the port itself and other business enterprises that will be established as direct linkages to the new Port projects, will be a sustained source of income to the local communities. In a more longer term, this will result in the improved living conditions and prosperity of the local people, the reduction of the current high levels of poverty and in general, to the significant development of the region.

5.4.1.2. Influx of Immigrants

During the construction phase of the Project: it is expected that there will be a large influx of immigrants into the area, e.g. Project staff; those seeking skilled and unskilled jobs; itinerant traders; and a motley of those providing various kinds of services..This will of course at once swell the population of the Project activity sites – probably making the immigrants temporarily to outnumber the local inhabitants.

However Workers camps might also have adverse impacts in terms of labour influx in the area, which might further increase the pressure on the existing resources/infrastructure. At the same time, the positive impacts of the Project are expected to create more employment opportunities where fishermen might have a chance to acquire new skills, and increase commercial activity during the construction and operation of the Port.

Despite once in the operation phase, most of the immigrants will leave and the population will stabilize. a sizeable number is expected to remain – to be engaged in the vibrant economic activities created by the Project linkages. And this is likely to alter the demographic patterns of the local communities in the long run. In the long term, i.e. during the operation phase of the project, this may create a sense of resentment by the locals against the immigrants, thus jeopardizing the social cohesion among the area communities.

5.4.1.3. Balance

Anticipated Impact	Mitigation Measures	
	Construction	**Operation**
Increased opportunities for direct and indirect employment	Project developer has proposed to recruit 50%* of its workforce during construction, based on availability and skills, locally.	During operations, more skilled and technical manpower will be required and therefore, the project developer shall endeavour to recruit as much of its work force locally as possibly, if skills exist.
	Project developer shall require all its contractors and subcontractors to hire workforce locally. This requirement shall be included in the contractual agreements.	NA
	Project developer shall prepare a Local Hiring and Purchase Plan (LHPP). Plan shall include procedures & practices to maximise opportunities for hiring local workers, allowing access to jobs for the local population in an organised & fair manner.	Local Hiring and Purchase Plan (LHPP) should be updated prior to commencement of port operations and it should include measures for increasing local employment in operational phase as well.
		Implement skill development locally to improve employability of local population.

Table 52 Enayam Alternative Predicted Project Impacts on Employment Opportunities and Mitigation Measures

5.4.2. Impacts on Livelihood

During the **construction phase**, the following negative impacts are likely to happen

5.4.2.1. Loss of access to the beaches

Fishermen using the seashore which falls in the shadow area of Phase I will have to restrict access to the pocket beaches, as this part of the sea coast and beaches will be permanently lost due to reclamation and will be inaccessible for fishermen. Loss of these beaches during reclamation works will affect many fishermen who are engaged in shore seine, mussel and lobster collection. Movement of fishing vessels along this coastal stretch will also be hampered. Fishermen using these beaches shall have to either depend on the nearby fishing harbour or have to move to other beaches.

5.4.2.2. Loss of fishing ground in the marine area for breakwater, approach channel and exclusion zone:

Loss of fishing grounds occur for fisher folks using the area between the existing shoreline and up to the breakwater and the exclusion and impacted fishing grounds in the approach channel. Social survey established that a large number of fishermen from the villages were actively involved in fishing in the project stretch including mussel, lobster and shore seine fishing.

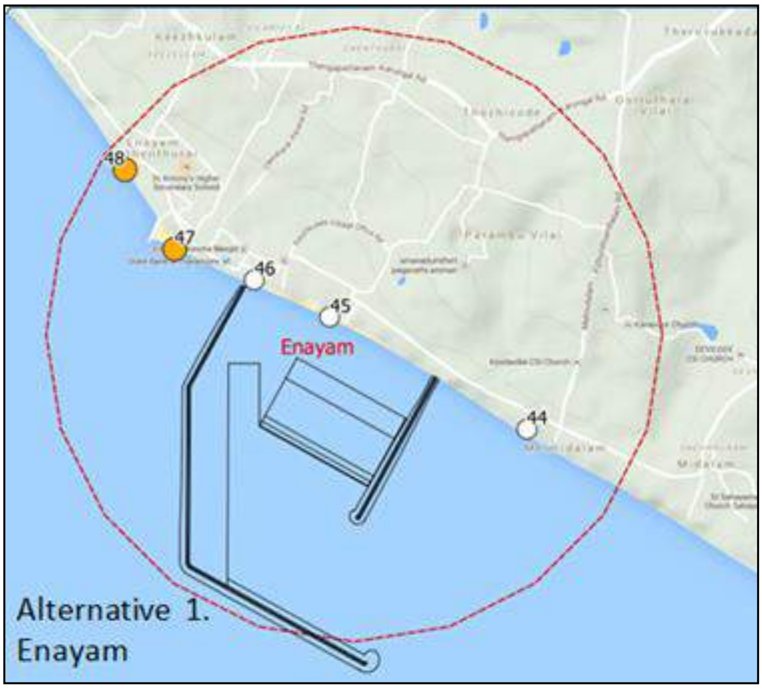
Breakwater will be at a distance of roughly 1500 m from the shoreline and its length is around 4 km. Therefore, marine fishing ground of area of about 600 Ha will be lost during phase I on account of breakwater alone. In addition to the 600 Ha area fishing ground lost to the breakwater, fishing grounds in the approach may be affected (due to fishing exclusion zone) although not physically separated from the rest of the sea.

The fishing ground present in the project stretch enclosed by the breakwater, where at present, fish catching activities for lobster, mussel collection and shore seine will be stopped. Fishing population, at present dependent on this patch of sea will lose their fishing ground and have to shift to some other part of coast and fishing ground in the sea beyond the port area. This might not be feasible for some people and will result in the loss of their livelihood. In addition to the active port area, the fishing activity will be hampered in the wide stretch of approach channel approx. 1.5 km away from the coast line. Because of this approach channel the „to and fro" movement of boats from the shore adjacent to the approach channel will be occasionally hampered during the movement of ships.

5.4.2.3. Obstructed access to the existing fishing harbour

During monsoon season, the fishermen from the northern and southern (about 10-15 Km) side of the Coalachel fishing harbour venture into the sea from the fishing harbour, since they cannot embark into the sea directly from their beaches due the rough sea. At the onset on monsoon, they bring their boats (through sea or by road through trucks) and dock the same in the Colachel fishing harbour, for a period of 2-3 months (monsoon) and will take back to their respective places after the monsoon. Due to the tranquil nature of the fishing harbour, fishermen could venture into the sea (and later land their fish), even if the sea is rough (in monsoon).

So as to reach the Çolachel harbour for docking their boats, prior to monsoon (and to take it back after monsoon), the fishermen on the southern side of the proposed port currently traverse through the proposed reclamation/dredging & port area. In future they might have to circumvent this area during construction and operation, by an additional distance of more than 3 km, (once while taking their boats to Colachel -Enayam and then once while taking back). This will have additional expenses on fuel, but will be limited to two trips per year per boat.



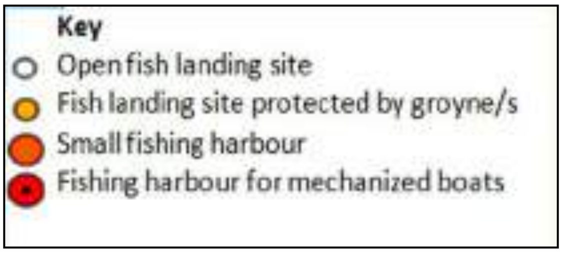


Figure 64: Enayam Port Area fish landing sites

5.4.2.4. Reduction in catch/yield:

During disposal of dredged material, turbidity might increase in the nearby marine area leading to decrease in fish catch, which in turn will reduce the income of the fishermen living along the coast in these regions. This is a short term impact. Expected quantity is very less and disposal will be in marine disposal borrow area. Loss of fishing ground in the active Port area including approach channel area will reduce the income of many fishermen, who at present operate in this part of sea.

As for the potential impacts **during operation**, the following have been identified

5.4.2.5. Permanent loss of fishing ground

Operation of terminals will reduce the effective fishing zone between Colachel and Enayam, created by the BW area and will have adverse impact on the total fish catch from that region. This will have significant adverse impact on the income generation of local fishermen active in this stretch. Fishing activity at the active port area will be permanently lost.

Fishing ground present in the project stretch enclosed by the BW where at present fishing activity like lobster, mussel collection, shore seine and fishing in open sea take place will be stopped. Fishing population, at present dependent on this patch of sea will lose their fishing ground and have to shift to some other part of coast & fishing ground in the sea beyond the port area. This might not be feasible for some people and will result in the loss of their livelihood. In addition to the active port area, the fishing activity will be hampered in the stretch of approach channel approx. 1.5 km away from the coast line. Because of this approach channel the „to and fro" movement of boats from the shore adjacent to the approach channel will be occasionally hampered during the movement of ships, which is estimated to be a maximum movement of three ships per day

5.4.2.6. Access to the existing fishing harbour

Fishermen residing in the villages located at the southern-east side of the proposed breakwater will be affected as their route to Colachel -Enayam fishing harbour passes through the proposed port area. To approach the harbour they will need to take a longer route encircling the port area at least 1500 m away from the present coastline, at present their route is through a distance of 300-500 m from the coastline.

But this is needed only twice in a year-once during their journey to Colachel harbour before monsoon and later back after the monsoon.

Only those families, which use the beach in the project area will experience some loss of income as dredging activities for approach channel will affect the availability of fish and affect the shoreseine fishing in this part of sea in near shore waters. Number of such fishermen is expected to be small and this is a temporary activity till the completion of dredging.

5.4.2.7. Increased mussel collection

At the construction stage as well as initial stage of operation, the port will have negative impact on the mussel production there by impacting the livelihood of the fishing population engaged in mussel collection. But after about 3 years from port operation it is expected that the breakwater surface will act as substratum for the growth of mussels where (on the outer side) they can be picked. The lost mussel fisheries will be re-established (roughly after 7 years from commencement of port construction) and provide livelihood for many.

5.4.2.8. Increased risk of accidents

Although movement of a maximum of three ships are only anticipated in phase I of the project, the crossing of fishing boats at this time has got the risk of accidents, if the marine traffic lanes are not clearly marked.

5.4.2.9. Mitigation Measures

- Additional fish landing space to ease the congestion at the existing fishing harbour during monsoon and to promote fish landings in harbour (fish landing in beaches are considered unhygienic as per EU standards, which in turn has an impact on export oriented fisheries)
- Improve the living conditions of those economically displaced by the Project;
- Aim to maintain or restore catch per unit of effort or catch per unit of cost;
- Design and implement, in a timely manner, culturally sensitive and economically sustainable

- income restoration measures;
- Provide measures and support for livelihood diversification;
- Identify and provide special assistance to people who are especially vulnerable to economic displacement impacts;
- Conduct consultation processes that achieve free, prior, and informed participation; and Monitor and evaluate to ensure that livelihood restoration measures are meeting the needs of affected people and to identify the need for, and implement corrective measures.
- The operational phase of the port will include terminal operations and maintenance dredging. The likely impacts of these activities are more or less similar to the impact of construction phase on fishery based livelihoods, which includes the following:
  - Permanent loss of beaches and fishing ground
  - Loss of income
  - An increased risk of accidents.

5.4.2.10. Balance

Anticipated Impact	Elgible PAPs (Fishermen)	Mitigation Measures	
		Construction	Operation
Loss of beaches	Fishing households (including boat and gear owners, crew members, labour) using the lost beaches for shore seine, boat launching and catch landing.	Transitional cash compensation equivalent to actual income lost till the new fishing harbour is ready or access to alternate beaches is provided. Preference shall be given to the affected fishermen households for jobs/employment subject to vacancy and suitability based on eligibility Provision of boats, fishing gear and other equipment to fishermen families A fishing harbour with landing terminals, road network, fish processing as well as auction area, ice plant, transportation facilities, drainage and solid waste management facilities) should be constructed with reserved rights to mooring/ berthing the boats for these fisher folk. Training programs will be organised in fisheries science/ management, supply boat construction, materials, and power equipment, tools and parts for equipment maintenance and repair, gear for improving fishing techniques, and training in Best Management Practices (BMPs).	Improved transport facilities to the new fishing harbour will be developed. Training programs as in the construction period shall be organised
Loss of fishing grounds in the marine area for BW, approach channel and exclusion zone	Fishing households (including boat and gear owners, crew members, labor) who lost access to the impacted fishing grounds.	One-off cash compensation	A fishing harbour with all the infrastructural facilities as in the construction period shall be provided

Anticipated Impact	Elgible PAPs (Fishermen)	Mitigation Measures	
		Construction	Operation
Loss of income	Fishermen (including boat and gear owners, crew members, labor) using beaches in the project footprint area for shore seine, boat launching and catch landing and Fishermen fishing in the area affected by the project.	Cash compensation for transitional loss of income till the new fishing harbour is ready or access to alternate beaches is provided.	Preferences shall be given to eligible candidates in matters of job/employment and appropriate training programs shall be organized for the fishermen folk as in the construction phase.
Damage and loss of gear, equipment and boats	Fishing households experiencing damage of their property because of Project activities.	Compensation at replacement cost for loss of equipment, gear and boats and reimbursement of cost of repairing damaged gear, equipment and boats.	All facilities as mentioned in the construction phase shall be provided

Table 53 Enayam Alternative Predicted Project Impacts on fishing activities and Mitigation Measures

5.4.3. Impact on Toruism Tourism infrastructures

Potential adverse impact is also anticipated on tourism which is dependent on beach resorts. Along the coastal stretch of the project site. tourism represent another economic activity in the area. These potential impacts are anticipated during the construction and operation phases. The rest of the tour are also not much affected as they can continue to do the business and it is independent of the beaches.

The visual quality of a project area is affected by the creation of a port, port facilities, lighting, and other optical disturbances. The landscape may be changed into an artificial scene of industrialization. Some port facilities may give an unpleasant impression to people. One major feature and tourist attraction lies on the Tamil Nadu west coast: Kanyakumari town, one of nine major centres of tourist attraction in Tamil Nadu, notable for pilgrimage and tourism. A total of 1.6 million tourists (96.7 % domestic visitors) visited Kanyakumari in 2010. It is known based on specific studies, that Kanyakumari tourist development may prove good destination for millions of tourist and generate lot of income and boost the local economy and their socio-economic development including improving their life style.

The most important places are mainly: Thiruvalluvar Statue, Vivekananda Rock Memorial, Kamarajar Manimandapam, Mahatama Gandhi Memorial and Bay Watch.
Another major cultural site is Colachel town, declared as a „heritage town" (G.O. Ms. No. 191 MA&WS department dated 18.07.1994). Tourism developments in the coast line are also present in Muttom and along the coast between Manakudi and Pallam.

5.4.4. Impacts on Land Use

5.4.4.1. Emergence of New Settlements

During the construction phase of the Project, there is likely to arise 3 new types of settlements around the project sites, viz:

(a) Labor camps – to cater for the influx of immigrants attracted to the area by prospects of job opportunities. These are likely to be demobilized upon the Project completion.

(b) Growth of the neighboring trading centers – as the new centers of the enhanced commercial and services activities linked to the Project operations. This growth trend is expected to sustain beyond the operation phase of the Project.

(c) Establishment of homes by some of the immigrants, who may decide to settle permanently in the area.

5.4.4.2. Rise in Land Prices

One of the most immediate impacts of a development project – with its attendant linkages to vibrant economic activities, is steep rise in land prices – as potential investors compete for suitable space to site their investments in the new land of opportunity. This has the effect of forcing out the locals farther into the interior – whilst the new settlements prosper.

5.4.4.3. Loss of land during construction and operation Phases

As the port is to be developed entirely on the **reclaimed land no land acquisition is envisaged for the port development**. (see next image)

However, as it can be easily appreciated in the map, the project shadow area can isolated fishermen dwellings. Unlike fishing village the families are not fully in to fishing occupation. Mostly these people are dependent on the Colachel-Enayam fishing harbour.

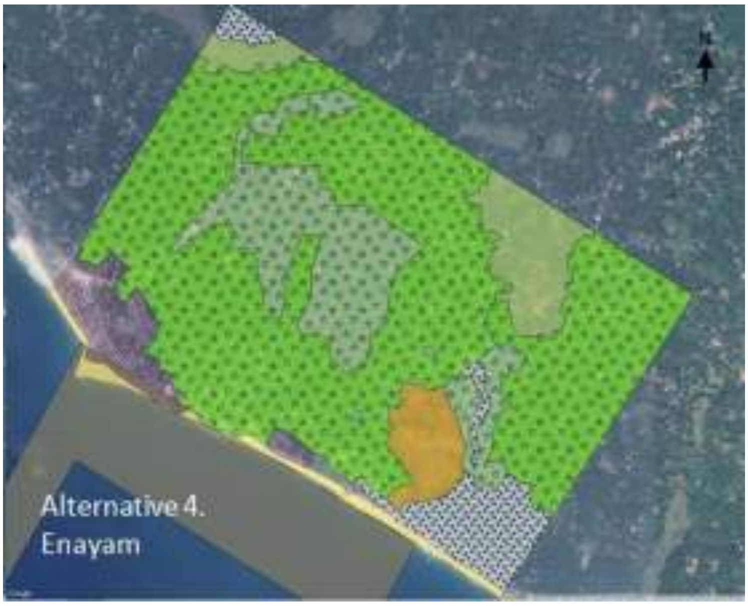
Coastal land-use from Colachel to Enayam will change to a Port area. As a result of the Project development, this part of the sea coast and beaches will be permanently lost during the construction
and operation of the Project

In addition for developing other facilities like road/rail connectivity, warehouse, residential areas, truck terminal etc require land in the vicinity. Future expansion of inland Port related activities such industries can may need extra areas which may impact on population and private properties. Relocation of the local community may cause conflicts with local people. .

Land owners (including resorts owners in that area) and land users will be affected by the loss of land and their livelihood might, if these are dependent on land, e.g agricultural activities. Reclamation, ancillary facilities, connectivity infrastructures (roads, etc) may affect land owners Land owners and land users.

Figure 65: Enayam Port Phase III Map

However the port being an international facility with multitude of infrastructure planned including defense requirements the port also require backup areas in the immediate vicinity It is estimated that the Port will need an inland extra area; although that area is not yet clearly defined we can assume a interval between 1.5 and 2 Km2. Following image shows the current land-use within the 2.5x2.5 Km square area for each port location.



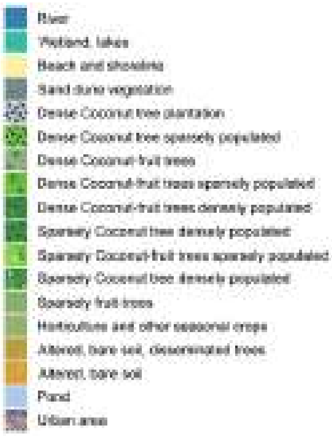
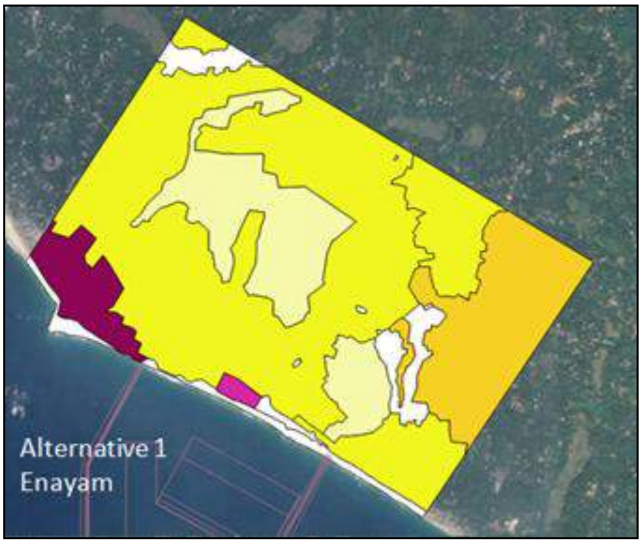


Figure 66: Enayam Port Area Land-Use Map

Despite further additional reclamation of land will be required for the marine facilities of port, as container yard and rail/road further connectivity& other yard infrastructure. (Port operators, truck terminal; warehouse etc.), in this phase of the project development only direct affection due to the implementation of the connectivity infrastructures will be considered for the evaluation of land/properties affection.

This land for the land side infrastructure (ancillary sites) would cater to the needs of following phases of Project development.

Following image shows in-land population density within the 2.5x2.5 Km square area for each port location.



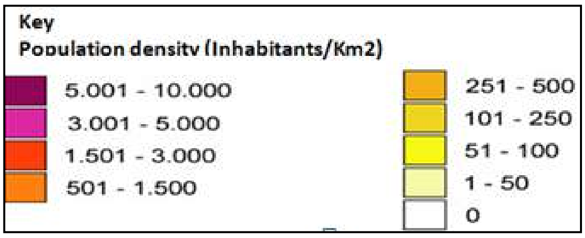


Figure 67: Enayam Port Area Population Density Map

Following table shows the estimation done.

Location	Land Use	Area (Km2)	No. of Households	Households/Km2
ENAYAM	Rural	6,2	384	326
	Urban	0,33	1.746	
	Total	6,54	2.130	

Table 54 Enayam Land use: Households/Km2

5.4.4.4. Extent of impact due to Road and rail connectivity

- Railway line

To determine the magnitude of the possible impact on the houses produced by the railway line linking Kallu Thotti - Marthandam Rd -Enayam Port we have proceeded as follows:

By means of photo-interpretation (Google Maps Physical) and with the help of GIS program we have identified and digitized the houses and buildings in the area. Digitization was performed at a scale 1: 2,500 identifying every single building detectable at that scale. Then a shape file of points, corresponding to the identified houses was created in the vicinity of the railway premises.

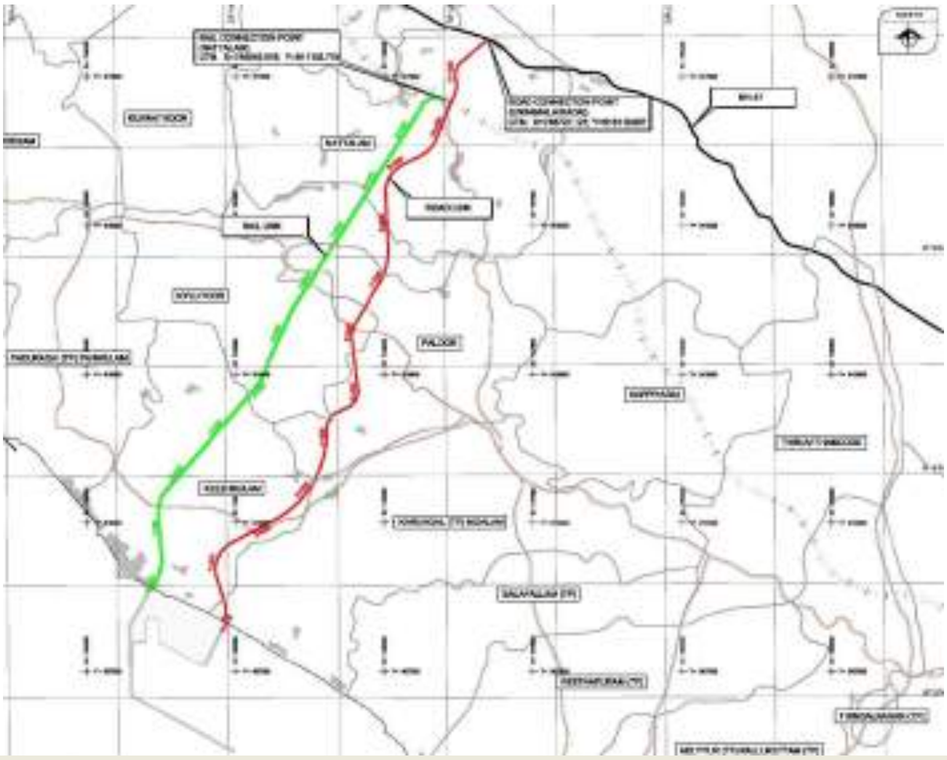


Figure 68: Rail (green line) and road (red line) connectivity. Villages affected

Figure 69: Houses in the vicinity of the proposed railway line premises

Once the buildings had been located, the shp file was intersected with the railroad trace (axis).For this, a buffer condition of 50 meters on each side of the axis of the rail was considered

Figure 70: Houses affected within the railway line premises

The results of are the following

RAILWAY	N° OF AFFECTED PROPERTIES
Alignment	4
Earth movement	81
Buffer 50 meters	159
Total	244

Considering a buffer of 100 m (affection band) a total number of **244 properties** would be affected for the railway line implementation.

- Road

Using the same methodology, all the properties in the vicinity of the road alignment were identified and located into a shp file. The shape file was intersected with the 10 m road alignment, considering in this case a band of affection (buffer) of 50 m

Figure 71: Houses in the vicinity of the proposed road alignment premises

The results of are the following

Figure 72: Houses affected within the road line premises

ROAD	N° OF AFFECTED PROPERTIES
Road	27
Buffer 25 meters	156
Total	183

Considering a buffer of 50 m (affection band) a total number of **183 properties** would be affected for the connection road implementation.

Under these premises, a total number of **427 properties would be directly affected** by the implementation of the railway line and road connections.

5.4.4.5. Mitigation Measures

Impact on private lands or properties as a result of land acquisition is related with population density. Impact can be minimized through the selection of low inhabited areas or through the inclusion of public terrains. As a part of compensation/mitigation work for the project a full Resettlement Action Plan must be prepared including an entitlement matrix for PAP as per policy for the proposed project.
Before the implementation of the project it must be assured that the local communities are satisfied with that framework and steps to been taken for proper compensation of the PAPs.

As a first step for the RAP a Breakup of Land Details must be provided, where the following should be clearly stated:

- The ownership of the properties
- A classification of the ownership of properties
- Type of buildings and housing infrastructure affected
- Extent of Land Lost by the PAFs, including Cumulative Loss of PAFs from Several Properties
- Religious and common property affected area

Following a **preliminary** entitlement matrix as for is included. With the development of the project design, this matrix must be completed and full detailed.

Impact Category	Type of Loss	Unit considered for entitlement	Entitlement
Entitlement matrix-PAP's of Road/Rail connectivity			
Title holder Private Property	Loss of land Project	Affected/ Displaced Family (PAFs/PDFs	• Land value through negotiated direct purchase • Value of structures (other than residence) in the land as fixed • Income restoration as per RAP,(if applicable as per the LA Act and R&R policy)
Title holder of Private Property	Loss of residential building	Project Displaced Family (PDF)	• Land value through negotiated direct purchase • Replacement value of the displaced structure as per enhanced PWD schedule of rates • of land (resettlement site) free of cost to the owners who surrender land with building, in nearby areas • Hardship allowances which includes livelihood allowance (one time) and rent for 6 months, as fixed by DLPC
Title holder of Private Property	Loss of commercial building	Project Displaced Persons (PDP)	• Land value through negotiated direct purchase • Replacement value of the displaced structure as per enhanced PWD schedule of rates • Hardship allowances which includes livelihood allowance (one time) and rent for 6 months, as fixed by DLPC
Titleholder Trust/Cooperative/ NGO, etc	Loss of Cultural property /Common property	PDP	• Land value through negotiated direct purchase • Replacement value of the displaced structure as per enhanced PWD schedule of rates • Provision of land as compensation, if decided as a replacement condition as per LA Act and R&R Policy

Impact Category	Type of Loss	Unit considered for entitlement	Entitlement
Property/ residence/ building, etc. partially affected	Loss of portion of land/Property (partially affected)	PAP	• Value of the land acquired through negotiated direct purchase • Compensation for the portion of the structure impacted as per valuation • Support to construct compound wall, etc. to protect the remaining land
Partially impacted common property resource	Private/Public ownership	Community	• Enhancement supports to reconstruct and recreate the lost/impacted portion • Provision of approach roads, etc. • Replacement/reconstruction at project cost in case of religious/cultural properties • In case of religious properties, expenses of rituals etc will be met by the project, as discussed and agreed with community committees
Non titleholder	Loss of land/ Residence without pattas/documents	Encroacher	• No compensation amount for land • Replacement value of the displaced structure as per enhanced PWD schedule of rates • Hardship allowances which includes livelihood allowance (once) and rent for as long as fixed by DLPC
Non titleholder	Loss of livelihood	Squatter	• Hardship allowances which includes livelihood • allowance (one time) and rent for 6 months, as fixed by DLPC • Income restoration programs as per RAP • Skill training if required
Non titleholder	Loss of Livelihood	Employees of displaced shops	• Livelihood allowance to employees with more than 3 years of service in the same organization, subject to a maximum of 2 number of persons • Skill training if required
Non title holders	Loss of livelihood	PAP	• Hardship allowances which includes Livelihood allowance (one time) and rent for 6 months, as fixed by DLPC • Income restoration programs as per RAP • Skill training if required
Entitlement Matrix - PAPs of Fishermen Community			
Fishermen in general	Inconvenience	Project affected communities	• A new fishing facility with all required infrastructure shall be constructed towards the southern side breakwater of existing fishing harbour with reserved rights to mooring/berthing the boats for these fisher folks and to fulfil the requirement, identity cards to be issued to these fisher folks to facilitate the exclusive right reserved for them. • Skill training if required shall be provided at Skill development centre
Mussel & Lobster collectors and related fisher folk	Permanent livelihood loss	PAF	• One time livelihood compensation per family (family to be registered after cross verification) OR one outboard engine boat & net for five families together • Skill development training to those interested in other jobs • Weightage for jobs arising in the port and associated institutions based on qualifications & skill.

Impact Category	Type of Loss	Unit considered for entitlement	Entitlement
Shore seine fishing (6 months duration) at Enayam-Memidalm-Midalam (a) Fishermen as owners b) Active fishermen (c) Labourers	Permanent livelihood loss	PAP	• One time livelihood compensation per family (family to be registered after cross verification) OR one outboard engine boat & net for five families together • Skill development training to those interested in other jobs • Weightage for jobs arising in the port and associated institutions based on qualifications & skill.
Fishermen from surrounding Villages depending on Enayam-Colachel fishing harbour for 3 months duration during monsoon season	Temporary livelihood loss at construction phase	PAP	• Inconvenience allowance for 25 days in a month shall be provided for 3 months in a year for a period of three years of construction period. • Skill training if required
For women in the fishing communities within 2 km radii	Temporary livelihood loss at construction phase	Project Affected Person/Persons in group	• Provision of revolving fund to be organized and managed with thrift-credit operations, linkage banking, skill development training. • Income generation opportunities to provide additional income to families

Table 55 Impact on livelihood. Preliminary Entitlement Matrix.

5.4.4.6. Balance

Anticipated Impact	Extent and nature of the impact	Project Affected People	Project Activity	Mitigation Measures
Loss of Land	Coastal land-use from Colachel to Enayam will change to Phase-I to III Port area As a result of the Project development, 4 Km of the sea coast and beaches will be permanently lost during the construction and operation of the Project. Land owners and land users will be affected by the loss of land and their livelihood might, if these are dependent on land, e.g. agricultural activities	Land owners and land users	Reclamation, Road and rail connectivity	Compensation Full Resettlement Action Plan (RAP) at Project Design Phase.

Table 56 Enayam Alternative. Predicted Project Impacts on Livelihood and Mitigation Measures

6. ENVIRONMENTAL MANAGEMENT PLAN EMP&CSR

An Environmental Management Plan (EMP) can be defined as "an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of the projects are enhanced". EMPs are therefore important tools for ensuring that the management actions arising from Environmental Impact Assessment (EIA) processes are clearly defined and translated into an Environmental Management Plan (EMP) for the design, construction, operation and/or decommissioning phases of a project.

The Environmental Management Plan (EMP) has been prepared for all the components of the port (road/rail, ancillary sites) to address the potential environmental impacts. In this project both EMP measures and CSR measures are more or less identical and hence an appropriate institutional mechanism suggested.

The main objectives of Environmental Management are to:

- Accept the importance of the location and establish a clear environmental management vision for the region.
- Identify key environmental issues envisaged to be encountered during construction and operation phases of the project.
- Determine the CSR (Corporate Social Responsibility)
- Provide guidelines for appropriate mitigation measures.
- Establish systems and procedures for implementing mitigation measures.
- Ensure the mitigation measures are being implemented effectively.
- Monitor the effectiveness of mitigation measures.
- Take necessary prompt action when unforeseen impacts occur.

And finally the **green stamp by Head of EMP/CSR** cell must be made mandatory for execution of all activities (civil/mechanical/electrical/administrative, etc.) with a clear logically correct **EMP/Sustainability note.**

6.1. INTITUTIONAL REQUIREMENTS

The effective implementation and close supervision of the environmental management to mitigate the environmental impacts, which are likely to arise due to the construction and operational phases of the project could be achieved through a suitable institutional mechanism.

A proper institutional mechanism to understand and implement appropriate environmental management measures during various stages of the project is a pre requisite and has a strong bearing for the overall success of the project management. Implementation of the Environmental Management measures will become easy once a good project management team is in place

The Port Authority can adopt **Environment, Health & Safety Management System** (EHS MS) based on recognized international standards for environmental and safety management systems (ISO 14001 – 2008; OHSAS 18001- 2007, 2008, Social Accountability (SA) 8000 and International Maritime Organisation (IMO)). 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. The typical procedure that can be adopted in formulating the EMS is presented below:

- Identify and list out environmental aspects due to the operation of the proposed project

- Determine the key operations that have significant environmental impacts
- Identify and track environmental legislations, policies, codes and other relevant requirements
- Establish objectives and targets (Environmental Management Plan)
- Formulate an Environmental Management System
- For successful implementation of the formulated Environmental Management System, Port Authority shall ensure that the essential resources (with defined roles and responsibilities) are made available to implement, maintain and improve the Environmental Management System.

6.1.1. Environmental Management Cell (EMC)

Apart from having an Environmental Management Plan, it is so also necessary to have a permanent organizational set up charged with the task of ensuring its effective implementation of mitigation measures and to conduct environmental monitoring. PORT AUTHORITY shall have a well-structured Environmental Monitoring Cell (**EMC**), staffed with qualified manpower and a well-equipped laboratory. The EMC is responsible for overall environmental activities of the port and implementation of the Environmental Management Plan (EMP). The EMC" s responsibility for implementing the EMP also requires regular interaction with the environment regulatory authorities such as TNSPCB, **MoEF** and the Indian Coast Guard.

The major duties and responsibilities of Environment Management Cell are:

- To implement the environmental management plan
- Risk identification and control of environmental problems
- Evaluating the efficacy of the EIA, mitigation measures, as stipulated in the EMP.
- Coordination with MoEF and other central/state pollution control boards for prevention and control of pollution.
- To assure regulatory compliance with all relevant rules and regulations
- To ensure regular operation and maintenance of pollution control devices
- To minimize environmental impacts of operations by strict adherence to the EMP
- To initiate environmental monitoring as per approved schedule
- Review and interpretation of monitoring as per approved schedule
- Review and interpretation of monitoring results and corrective measures in case of monitored results are above the specified limit
- Maintain documentation of good environmental practices and applicable environmental laws as ready reference
- Maintain environmental related records
- Coordination with regulatory agencies, external consultant, monitoring laboratories
- Maintain log of public complaints regarding environmental issues and the action taken

Over a period of time a system to understand and absorb the new revisions and changes in the environmental requirements and practices are to be established. This can only be achieved by regular training and genuine capacity building initiatives. All this require a sound positive attitude of top level management towards environmental management.

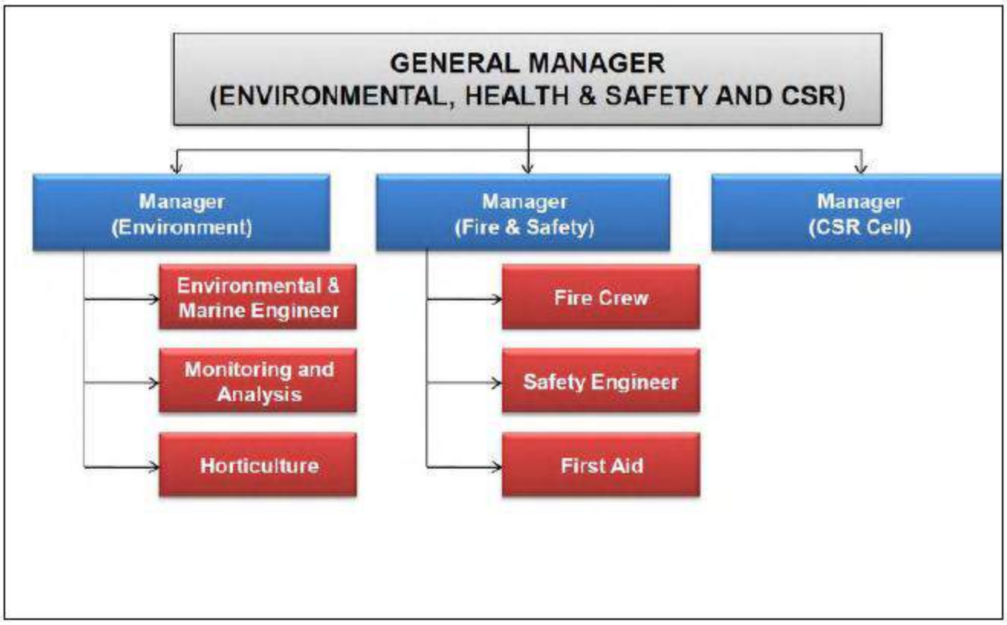


Figure 73: Organizational Setup for Environmental Management Cell

6.1.2. Contractors EMP

Contractor is to prepare an implementable contractors EMP to address all construction related environmental impacts. This has to be approved by Port Authority prior to implementation. Environmental monitoring consultant appointed by Port Authority for the implementation of EMP will ensure the finalization of an implementable contactors EMP during construction phase.

The same environmental consultant will supervise the implementation of the EMP as well. The major activities under the EMP are:

- Labour camp with water, power, sanitation and medical, etc.
- Community grievance management
- Waste Management
- Plan Local Employment Plan
- Dredge and Reclamation
- Area Management
- Water Management
- Quarry and transport management Plan
- Air Quality and Dust Management Plan
- Personal Protective Equipment
- Natural Resource Management Plan
- Health, Safety & Hygiene Measures
- Transport Management Plan

6.1.3. The Environmental Management Team

In order to achieve all set goals, a highly committed project management team will be required during Construction Phase. The success of implementation of various EMP measures largely depends on the commitment of project management team with a clear vision. The dedicated environmental management team will drive the action with:

- Adequate space and room
- Capital cost and recurring budget
- Adequate trained staff, vehicles on demand and IT support facilities
- Clear lead role to main stream environment
- Contractor EMP for construction phase
- Operational EMP for Colachel-Enayam port

This unit will be the starting point of recommendation to the management with regards to CSR and EMP activities The environmental management team should have extensive, detailed local knowledge of shoreline habitats and species likely to be affected by clean-up operations. All clean up operations shall be based on the zero left over concept for termination of cleanup operation with the all available latest technologies. The team should be able to provide advice on human health, ecological and amenity interests. Working in close co-operation with the technical team, this team should fulfil several basic functions, including provision of advice on:

- Risk and vulnerability of environmental features due to oil pollution.
- Possible/probable impacts of the oil.
- Priority for protection of sensitive sites.
- Effect of clean-up methods on the local environment.
- Potential and real effects on human health.
- Help to implement the chosen strategies.
- Monitoring and ensuring that priorities of clean-up techniques adequately reflect environmental concerns.
- Coordinating all environmental monitoring and sampling programmes.
- Providing liaison links with other interested environmental organisations.

6.1.4. Corporate Social Responsibility (CSR)

At this phase of the project development (Rapid Feasibility Report) and after the analysis done in previous chapters of the project area socioeconomic tissue and before the main conclusions obtained, as a part of the further Corporate Social Responsibility (CSR) of the final Detailed Design some actions are proposed to compensate the impact of the construction and operation of the new port.

Planned activities to be included (but not limited to) in the final CSR should be the following:

- A water supply scheme for the Enayam fishing village.
- Creation of a new fishing harbour in Enayam like existing fishing harbour in Colachel The implementation of a new further fish landing centre in Enayam , including a cold store, must be considered in the Final Project Design. And a realistic budget should be estimated.
- Skill development centre for new marine port
- Preparation of a "port city" area development plan to be integrated with Enayam and Colachel city development plan

6.1.5. Institutional Setup of EMP and CSR Cell

The EMP cell needs to be a decision making unit of the entire management mechanism. Therefore is important either to have full-fledged EMP cell with all staff or to have a lean unit with hired consultants fulltime on call.

- Head of EMP and CSR cell also need to be at least on a third level of hierarchy:
- Chief Executive Officer (CEO)
- Chief Operating officer (COO) and Port Security Officer (PSO)
- HODs of all sections
- Within EMP cell both CSR section and EMP section. The CSR section need to have professional preferably an expert from the Social angle and the EMP cell must have a professional preferably a strong environmental management professional.
- There must be decentralised environmental managers that will have independent or composite charges of the decentralised units.

6.1.6. Administrative and Technical Setup for Environmental Management

A highly qualified and experienced people in the field of Environmental Management of port shall be considered for the position of Senior Manager for Environmental Management along with adequate supporting staff. The responsibilities of the Environmental Management Team shall be as follows:

- Identify environmental aspects, normal, abnormal and emergency conditions
- Ensure implementation of standard operating procedures as updated from time to time
- Evaluate any non-conformity to the environmental standards, as stipulated by different regulatory agencies
- Ensure and implement necessary corrective actions
- Establish procedures for reporting, document and record control
- Establish and implement procedures for incident and near miss reporting, investigation and root cause analysis and prescribe corrective action

6.2. COMPONENTS OF EMP AND CSR. MANAGEMENT ACTION PLANS

The environmental impact mitigation and avoidance measures for each likely impact on the prevailing environment have been discussed in detail at the respective sections. The following Management Action Plans (MAP) encompasses both EMP and CSR plans to address all issues comprehensively.

A Full detailed Environmental Management Plan and CSR should be established in the following Project Development Phases (Final Design and final ESIA Report) Thus, according to that final design the Final EMP and CSR will clearly establish the mitigation measures to be taken, the time schedule for their implementation and the roles and responsibilities for impact mitigation and compensation

From the conclusions of this Initial Environmental Examination, this section presents a preliminary Environmental Management Plan in matrix format.

In the following matrix the Agency ultimately responsible for monitoring compliance has been identified. For some management objectives it is possible that more than one monitoring agency is applicable, and in these cases careful and regular communication between the agencies is recommended.

6.2.1. Port Construction and Operation EMP matrix

The following table resumes the likely impacts expected due to Port construction and operation and the mitigation measures proposed, as detailed in previous chapters, the table also include the institutional responsibilities for their implementation.

N°	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
CONSTUCTION PHASE					
1	Capital dredging	Change in marine water quality	• Increase in turbidity • Change in marine water quality due to aqueous discharges (oily waste, sanitary wastes) from dredgers, barges and workboats	• Check turbidity levels with baseline levels as reference during entire monitoring program • Preparation of Dredge/reclamation Management plan • Discharge of waste into sea will be prohibited • Oil Spill control measures will be adopted Ensure that slop tanks will be provided to barges/ workboats for collection of liquid/ solid waste • Marine environmental monitoring as per environmental monitoring program	Construction Contractor/Port Authority/
		Marine Ecology	• Decrease in DO levels • Increase in noise levels • Removal of benthic communities • Increase in species diversity and density in areas adjoining dredging site • Smothering or blanketing of sub-tidal communities		
2	Material transport and construction activities	Air Quality	• Exhaust emissions from vehicles • Windblown dust during material movement • Fugitive dust during material unloading • Dust suspension during site preparation, construction	• Most of the Breakwater stones will be transported from the quarries to the nearest harbour. From there it will be transported through project site. This is will avoid substantiate flow of Heavy Vehicles during construction phase thereby minimizing impact on Air and Noise Quality in the project region. • To reduce impacts from exhausts, emission control norms will be enforced / adhered. • All the vehicles and construction machinery will be periodically checked to ensure compliance to the emission standards • Construction equipment and transport vehicles will be periodically washed to remove accumulated dirt Providing adequately sized construction yard for storage of construction materials, equipment tools, earthmoving equipment, etc • Provide enclosures on all sides of construction site • Movement of material will be mostly during	Construction Contractor/ Port Authority /

N°	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
				non-peak hours. • On-site vehicle speeds will be controlled to reduce excessive dust suspension in air and dispersion by traffic • Water sprinkling will be carried out to suppress fugitive dust • Environmental awareness program will be for vehicles engaged in transportation	
2	Material transport and construction activities	Noise	Noise from following activities: • Vehicles transporting construction material • Diesel run engines of construction machinery and dredgers • Pile driving activities during construction of cargo berths	• Noise levels will be maintained below threshold levels stipulated by Central/Tamil Nadu State Pollution Control Board (CPCB)/TNSPCB • Procurement of machinery / construction equipment will be done in accordance with specifications conforming to source noise levels less than 75 dB (A) • Well-maintained construction equipment, which meets the regulatory standards for source noise levels, will be used • Noise attenuation will be practised for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers • High noise generating activities such as piling and drilling will be scheduled at daytime (6.00 am to 10 pm) to minimise noise impacts • Personnel exposed to noise levels beyond threshold limits will be provided with protective gear like earplugs, muffs, etc. • Ambient noise levels will be monitored at regular intervals	Construction Contractor/ Port Authority /

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
2	Material transport and construction activities	Disturbance to Natural Drainage pattern	• Impact to natural flow of runoff due to blockage and change of drainage course	• Port development is mostly on reclamation • Rain water/surface water harvesting pond included in design • Existing drainage near port boundary (backup area) will be integrated with port storm water drainage & management plan • Existing drains Streams that are passing in ware house area will not be closed/ diverted. These streams will be desilted and enhanced to improve their carrying capacities	Construction Contractor/ Port Authority /
		Vegetation and Strain on Existing infrastructure	• Loss of vegetation and strain on existing infrastructure	• Port development is planned mostly on reclaimed land; • Land use at backup area, PAF Zone and warehouse area will be mostly coconut plantation and low mixed plantation • Adequate green belt will be developed in port and its associated (road & rail connectivity). • Temporary workers camp with self sufficient infrastructure facilities.	
		Existing Traffic	• Traffic Addition	• Road bypass under construction around 2.0 km m from the proposed Port site and the transportation of construction materials will be carried out during non- peak hours. • Regularization of truck movement • A dedicated rail network of approximately 15 km is proposed from port to next railway station	
3	Land Reclamation	Existing Water Resources like Groundwater and surface water	• The area along the coast is partly intertidal land, rocky cliff	• Land to be reclaimed will be separated from adjoining land by creating containment bund. • Return sea water will be sent back to sea through appropriate channels.	Port Authority /Construction Contractor
4	Solid Waste Management	Soil Quality	• Impacts due to disposal of solid waste on ground • without treatment	• Construction waste will be used within port site for filling of low lying areas. • Other recyclable wastes will be sold.	Port Authority /Construction Contractor

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
				• General refuse generated on-site will be collected in waste skips and separated from construction waste. • Burning of refuse at construction sites will be prohibited. • All control measure will be taken to avoid the contamination of groundwater during construction phase	
5	Handling of hazardous wastes	Human safety and property loss	• Fire accidents due to hazardous material handling	• Adequate safety measures standards will be adopted • Construction site will be secured by fencing with controlled/limited entry points. • Hazardous materials such as lubricants, paints, compressed gases, and varnishes etc., will be stored as per the prescribed/approved safety norms. • Construction site will be secured by fencing with controlled/ limited entry points • Medical facilities including first aid will be available for attending to injured workers. • Positive isolation procedures will be adhered • Hazardous wastes will be disposed through approved TNSPCB/CPCB vendors.	Port Authority / Contractor/
6	Water Resources	Water Scarcity/Pollution	• Impacts to surface water bodies	• Avoid/minimise the loss during conveyance • Optimized utilization of the water • Care will be taken to prevent the runoff from the construction site to the nearby natural streams, if any	Port Authority /

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
7	Fishing	Fishermen and fishing villages	• Impact on fishing due to construction works	• Signboards will be placed at the construction activities in order to make fishermen aware of the ongoing construction activities • Necessary marker buoys will be installed Interactions will be initiated with the fishing community before commencement of construction works	Port Authority / Contractor/
8	Breakwater	Change in shoreline	• Erosion and accretion along the coast	• Shoreline monitoring shall be carried • Suitable Shoreline protection measures will be implemented based on observations	Port Authority /
9	Effect on existing fishing harbour	Movement of fishing boats	• Restriction on free movement of fishing boats to/ from fishing harbour • Tranquillity in fishing harbour • Loss of livelihood	• Traffic of Marine vessel/ fishing boats will be planned without affecting each other • Adoption of fishing harbour to manage A new fishing harbour in Enayam should be provided under CSR initiatives • Loss of livelihood will be either take care of in the new port premises or adequately compensated mostly in the form of employment	Port Authority /
10	Shoreline changes	Erosion/accretion	• Loosing of beach area • Impact on houses/ structures along the coast	• Final Shoreline Impact Management Plan must be prepared in consultation with agencies like CESS/INCOIS, NGO and local bodies and will be implemented.	Port Authority /

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
OPERATIONAL PHASE					
1	Cargo handling and Inland Cargo movement and storage areas	Air Quality	• Emissions from DG sets (during Power failure), RTGCs vehicular emissions	• Use of Multi Purpose Cranes with provision of electric RTGs in future. • Regularization of truck movement • Periodic cleaning of cargo spills. • Use of tarpaulin covers and speed regulations for vehicles engaged in transportation	Port Authority to provide regulations to vessel operators /
		Noise	• Due to equipment handling and vehicular movement	• Acoustic Barriers and Enclosures • Personal Protecting Equipment (PPE) • Counselling and traffic regulation	
		Traffic Addition	• Cargo movement from/to port	• Dedicated road network • Regularization of truck movement • dedicated rail network of from port to railway station	
2	Aqueous discharges in harbour basin	Marine water quality and ecology	• Change in marine water quality/ecology due to discharge ship wastes (spillage), sewage, bilge water, solid waste etc.	• Ships are prohibited from discharging wastewater, bilge, oil wastes, etc. into the near-shore as well as harbour waters. • Ships would also comply with the MARPOL convention. • Oil spill contingency plan to be prepared and implemented. • Provision of waste reception facility	Port Authority to provide regulations to vessel operators/
3	Cargo and Oil spills	Marine water quality and ecology	• Change in marine water quality	• In case of any cargo spillage during transfer from/to ships, it will be attempted to recover the spills. • Oil spill control equipment such as booms / barriers will be provided for containment and skimmers will be provided for recovery. • Response time for shutting down the fuelling, containment and recovery will be quicker.	Port Authority to provide regulations to vessel operators
4	Maintenance	Marine water quality	• Increase in turbidity	• As per design, bathymetry, oceanographic	Dredging

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
OPERATIONAL PHASE					
	dredging	Marine Ecology	• Due to decrease in DO levels which effect marine ecology and disturbance to benthic communities.	conditions and modelling results quantity of dredge negligible. Maintenance dredged material will be dumped at the identified offshore disposal area for capital dredged material. • Additional Environmental Monitoring Programme comprising of monitoring of marine water quality, marine sediment quality and marine ecology will be initiated one week prior to commencement of dredging and will be carried out during the dredging period.	Contractor/Port Authority/
5	Water Supply	Water resources	• Impact on existing water resources	• Water treatment plant, storage and distribution network developed	Port Authority/Operator
6	Wastewater Discharge	Water Quality	• Impact due to discharge of runoff from container storage and sewage from port and port colony premises	• Separate Collection and treatment for oil and grease for runoff from workshop area, truck parking etc • Sewage treatment plant to be constructed within port area and port colony area	Port Authority/Operator/
7	Solid Waste Management	Groundwater and Soil quality	• Impact due to disposal of solid waste on ground without treatment	• An integrated solid waste management plan is proposed for port and associated facilities • Composted bio-degradable waste will be used as manure in greenbelt. • Other recyclable wastes will be sold.	Port Authority/Operator/
8	Fishing activity	Fishermen livelihood	• Impact on fishing due to vessel movement	• Educating the fishermen about the orientation of approach channel and movement of ships • Regular Interactions will be initiated with the fishing community • Conflicts if any with fishing community will be amicably resolved in all cases • A fishing harbour with all the required infrastructural facilities (i.e.,landing terminals, road network, fish processing as well as auction area, ice plant, transportation	Port Authority /

Nº	Activity	Relevant Environmental Components to be affected	Likely Impacts	Proposed Mitigation Measures	Responsible Agency for Implementation
OPERATIONAL PHASE					
				facilities, drainage and solid waste management facilities) should be constructed. • Fishermen using the beaches for mussel (brown mussel) collection and for shore seine in the project footprint area will be compensated with either alternate employment or to be suitably integrated to the new fishing harbour /port activities	
9	Breakwaters	Shoreline	• Changes in shoreline adjacent to Port. Erosion/accretion • Loosing of beach area Impact on houses/ structures along the coast	• Mathematical model to study and predict the shoreline changes due to the presence of breakwaters should be carried out • Shoreline monitoring should be carried. Final Shoreline Impact Management plan must be prepared in consultation with agencies like CESS/INCOIS, NGO and local bodies and will implemented. • Suitable Shoreline protection measures will be implemented based on the observations	Port Authority /
10	Operation of Port	Marine Environment	• Natural Hazards .	• Disaster Management Plan (DMP) should be prepared; Manager (EHS) will act as the overall in-charge of the control of educative, protective and rehabilitation activities to ensure least damage to life and property.	Port Authority /

Table 57 EMP Port Construction and Operation Potential Impacts and Mitigation Measures of Various Project Activities.

6.2.2. Road and railway corridors. EMP matrix

The following matrix resumes the likely impacts expected due to the implementation of the access road and railway corridors, both for construction and operational phases. as well as the mitigation measures proposed, (as detailed in previous chapters) including the time frame for their implementation..

Finally the institutional responsibilities for their implementation are also fully detailed.

Nº	Likely Impacts	Proposed Mitigation Measures	Time frame	Implementing Organization	Responsible Agency for Implementation
CONSTUCTION PHASE					
1	Dust	• During the construction phase water spraying is needed to aid compaction of the material. After the compaction, water spraying should be carried out at regular intervals to prevent dust. • Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During the Construction phase		PORT AUTHORITY /Consultants
2	Air Pollution	• Vehicles and machinery are to be maintained so that emissions conform to National and State standards. • All vehicles and machineries should obtain Pollution Under Control Certificates (PUC).	Beginning with and continuing throughout construction phase		PORT AUTHORITY / Consultants
3	Noise	• Construction of noise barriers of an average length of 100m and eight feet height where ever necessary. • Proper maintenance of the rail track and rail wagon, by frequent lubrication to avoid frictional noise. • Regular monitoring shall be carried out as per the Environmental Monitoring Plan.	Beginning and throughout construction phase		PORT AUTHORITY /Consultants
4	Loss of low lying land and ponds	• Impacted ponds can be enhanced by constructing bridged structures like Gabions to avoid plugging of springs. • Any pond hit During Construction phase will be compensated t and an equivalent area lost may compensate the loss of effective pond area. • Filling of low lying areas like paddy fields shall be done	During the Construction phase		PORT AUTHORITY /Consultants
5	Flood Impacts and Cross Drainage Structures	• Formation level should be raised according to the design and the cross drainage structures suitably planned for the flood events.	During construction phase		PORT AUTHORITY / Consultants
6	Alteration of drainage	• In sections along watercourses, earth and stone will be properly disposed of so as not to block rivers and streams, thereby preventing any adverse impact on water quality. • All necessary measures shall be taken to prevent earthworks and stone works from impeding cross drainage at streams and 7canals or existing irrigation and drainage systems in c8onformity to the Contractors visual integration and management plan and EMP.	During construction Phase		PORT AUTHORITY / Consultants
7	Contamination from Wastes	• All justifiable measures will be taken to prevent the wastewater produced during construction from entering directly into rivers and irrigation systems	Throughout construction phase		PORT AUTHORITY / Consultants

Nº	Likely Impacts	Proposed Mitigation Measures	Time frame	Implementing Organization	Responsible Agency for Implementation
8	Borrow pits	• Borrow pits are to be identified, opened and closed after consultations and proper documentation	Throughout construction phase		PORT AUTHORITY / Consultants
9	Quarrying and Material sources	• Quarrying will be carried out at approved and licensed quarriesonly.	Throughout construction phase		PORT AUTHORITY / Consultants
10	Soil Erosion and Soil Conservation	• On slopes and other suitable places along the two proposed corridors, trees and grass should be planted. • On sections with filling and deep cutting their slopes should be covered by sod, or planted with grass, etc. • If existing irrigation and drainage system, ponds are damaged, they will be suitably repaired. • Retaining walls and gabions shall be suitably provided	During construction and upon completion of construction activities at these sites.		PORT AUTHORITY / Consultants
11	Loss of agricultural topsoil	• Arable land should not be used for topsoil borrowing. • Topsoil will be kept and reused after excavation is over. • Any surplus to be used on productive agricultural land.	During construction phase		PORT AUTHORITY / Consultants
12	Compaction of soil and damage to vegetation	• Construction vehicles should operate within the Corridor of Impact avoiding damage to soil and vegetation.	During construction		PORT AUTHORITY / Consultants
13	Loss of trees	• Landscaping shall be done at major junctions. • Areas of trees cleared will be replaced according to Compensatory Afforestation Policy under the Forest Conservation Act - 1980.	After completion of construction activities	/ Forest Department	PORT AUTHORITY / Consultants
14	Vegetation clearance	• Tree clearing within the ROW should be avoided beyond that which is is directly required for construction activities and / or to reduce accidents. Especially in plantation and house garden areas both along road and rail alignment.	During cleaning operations		PORT AUTHORITY / Consultants
15	Fauna	• Construction workers should protect natural resources and animals. Hunting of birds and other local animals is prohibited.	During construction phase		PORT AUTHORITY / Consultants
16	Health and Safety	• All contractors" staff and workers must wear high visibility purpose made overalls or trousers/a waist coat at all times • All operators working with any materials above head height (even in trenches) must wear hard hats all at times on the worksite.	During construction phase		PORT AUTHORITY / Consultants
17	Water streams pollution	• Construction material / waste should be disposed of properly so as not to block or pollute streams or ponds with special attention to	During construction phase		PORT AUTHORITY / Consultants

Nº	Likely Impacts	Proposed Mitigation Measures	Time frame	Implementing Organization	Responsible Agency for Implementation
		confining concrete work.			
18	Cultural Remains	• Construction should be stopped until authorized Department assess the remains to preserve Archaeological relics and cultural structures like temples, mosques and churches. • Archaeologists will supervise the excavation to avoid any damage in the relics	Throughout construction phase		PORT AUTHORITY / Consultants/ Archaeology Department
OPERATTIONAL PHASE					
1	Noise	• Use of sound barriers or other measures should be considered. • Public will be informed about the regulations on noise of vehicles.	After completion of construction.		PORT AUTHORITY / Consultants
2	Contamination from spills due to traffic movement.	• Proposed road and rail corridors are dedicated to Port traffic. Moreover, the type of cargo is container cargo only along the alignments. • In case of any contamination then the measures described in the PORT EIA will be triggered	After completion of construction.		PORT AUTHORITY
3	Maintenance of Storm Water Drainage System	• Drainage systems will be maintained to accommodate storm water flow.	Especially at the beginning and end of monsoon		PORT AUTHORITY / Consultants
4	Erosion of Altered Road embankments	• Stabilisation of raised Paddy field areas by rip rap, gabions, retaining walls, etc.	Immediately after construction		PORT AUTHORITY / Consultants
5	Solid waste disposal.	• Water bodies, Ponds or canals need to be covered by side walls or screens. • Signboards shall be installed propagating that not to pollute environment and to keep neat and clean	During Operation phase		PORT AUTHORITY / Consultants
6	Loss of drinking water source (open/Bore wells)	• Bore wells shall be suitably replaced. Compensation shall be paid for the impacted open/bore wells • If the water supply disrupted alternative arrangements shall be made until the supply reinstated.	During Construction and Operation phase		PORT AUTHORITY / Consultants

Table 58 EMP Road and Railway corridors Potential Impacts and Mitigation Measures.

6.3. MONITORING AND REPORTING

Environmental and social performance monitoring of EMP and CSR activities should be undertaken to ensure that mitigation measures are implemented and results achieved during construction and operational phases.

Performance monitoring is relevant during the execution of works by external contractors, particularly during the construction stage, but also for major maintenance works and decommissioning during the post-construction phases.

Additional remedial measures may be undertaken if mitigation measures are inadequate or the impacts have been underestimated in the EIA report, in particular where the Project would be in breach of permits, National standards and IFC requirements and guidelines. Monitoring requirements have been divided into two main groups:

- Performance monitoring of the professional working practice of the Contractor and the implementation of mitigation measures by the work contractor(s);
- Direct monitoring of the effectiveness of mitigation measures during the operational phase of the different Project components.

6.3.1. Monitoring Plan for Construction

From a monitoring point of view, the important parameters are water, air, noise, soil, sediment, plankton, benthos and occupational health. A detailed monitoring Plan should be established in the in the following Project Development Phases (Final Design and final ESIA Report) according to the final design parameters and the conclusions of the Final ESIA Report.

The sampling and analysis proposed in the monitoring plan shall be carried out by the construction Contractor under the supervision of Port Authority.

The monitoring of water bodies inclusive of coastal sea water, inland surface water, groundwater, sewage, effluent and storm water etc will be a very important focal point of monitoring mechanism to ensure that there is positive improvement in quality of all these streams. Further the solid waste management (otherwise entering the sea through two streams) need to be made zero through waste management plans.

Monitoring and analysis shall be carried out following methods suggested guidelines of GOI-MoEF in particular. Only laboratories approved by MoEF or National Accreditation Board for Testing and Calibration Laboratories (NABL), Government of India shall be appointed for implementation of this monitoring plan.

Apart from the proposed monitoring framework, greenhouse gas emissions, carbon foot print etc. shall be monitored to judge the environmental strengths and weaknesses annually on the basis of Environmental Code of Practice (2003) delineated by the European Sea Ports Organisation (ESPO).

Monitoring of sourcing of material (Quarry material from Quarry and Borrow material from borrow areas) although this could be away from the PIA of 10 km radii for all regulatory clearances and approvals, this also being project induced impacts need to be monitored to avoid any potential impacts to the local communities. Monitoring details for quarrying are not included in the aforementioned frame, it is given separately, which shall be implemented and supervised by quarry operator. The following parameters shall be monitored during quarrying.

o Noise (except blasting) shall be monitored continuously in compliance with the Ambient Air Quality Standards and in Respect of Noise, The Noise Pollution (Regulation and Control) Rules, 2000.
o Record of occupational accidents, diseases, and dangerous occurrences, etc. shall be kept.

6.3.2. Monitoring Plan for Operational phase

During the operational phase, Port Authority shall be responsible for monitoring project activities even when activities are out-sourced to third parties (Supervision consultants).

The Port Authority should develop a separate operational EMP for the operation of the different components of the Project (port, transport via railway and road, storage, etc.). The implementation of the EMP should be the responsibility of the EMC within the project complex, which reports on a regular basis (e.g. monthly) to the management. The main tasks of this Environmental Management and CSR management Cell (EMC & CSR Cell) are in the field of:

- Monitor environmental quality. This monitoring is related to various aspects, such as air quality, water quality (supply and waste water), marine water quality and noise. Environmental conditions are to meet National standards and IFC guidelines. Prior to project operations, Port Authority should formulate a plan for monitoring ambient quality parameters, in consultation with the relevant authorities.
- Implement the Health and Safety Management Plan, which is directed at the well-being (health and safety) of the employees, Labourers and the population in the Project" s vicinity, directly affected by the project.

6.3.3. Reporting

As a part of environmental monitoring programmed, compliance reports shall be submitted to TNSPCB and Regional Office of MoEF., this would be at least the following:

- Every six months: Compliance reports in respect of the stipulated prior environmental clearance terms and conditions on June 01, and December 01, of every calendar year.
- Environmental statement for the financial year ending March 31, to TNSPCB
- Format for maintaining records of hazardous waste if any in Form 3 as per Hazardous Waste (Management, Handling and Transboundary movement) Rules, 2008.
- Format for maintaining hazardous waste imported and exported in Form 10 as per Hazardous Waste (Management, Handling and Transboundary movement) Rules, 2008.
- Safety data sheet for hazardous chemicals shall be maintained as per schedule 9 of MSIHC rules, 1989 (amended 2000).
- Format for maintaining notification of major accident in schedule 6 as per MISHC rules, 1989 (amended 2000).
- Water Cess returns in Form 1 as per Rule 4 (1) of Water (Prevention & Control of Pollution) Cess Rules 1978

6.4. BUDGETARY STIMATES FOR ENVIRONMENTAL MANAGEMENT

Again, considering the level of definition of the Project and the mitigation measures proposed a preliminary budget for port construction (reclamation) and implementation of the access road and railway corridors is included for the environmental measures proposed. The scope of this preliminary provision of funds budget excludes backup areas and the rest land side infrastructure (ancillary sites), since those cannot be estimated at this preliminary stage of the Project-EIA definition. It does not include planting and Landscaping measures.

The following is a preliminary environmental budget plan to address all environmental management requirements., the budgetary provision required to achieve this will be naturally high. Some of the key areas identified are the following:

- Environmental (terrestrial and marine) monitoring in both construction and operation phase Monitoring of Shoreline changes in Colachel-Enayam coast in both construction and operation phase
- Water & wastewater management. Solid waste management.,
- Groundwater development at Project Area. Focused water supply augmentation study in the 5 km study area. Storm water management and Rainwater harvesting is also planned
- Employment for solid waste management using Women Self Help Groups (SHG)-
- Fishermen who lost livelihood opportunities will be given preference in providing employment, scavenger boat operations. STP operators for the streams will be from those groups who lost Livelihood opportunities
- Rainwater harvesting, desiltation using silt traps, solid waste removal using waste trap, flow tank for spill over, collection tank, sump from where the water will be pumped to the various locations and also for the excess water to be drained to the sea by a naturally controlled mechanism.
- Sanitation facility at new fishing harbour for the entire fishing village Enayam. Bathing rooms.

6.4.1. Environmental budget

The budgetary preliminary estimate for Environmental Management for proposed port, road and railway alignment during construction phase is Rs 292Million (29 Crores) and the annual budgetary estimate during operational phase is Rs 20 Million

The breakup of annual environmental management cost of port and other land ward infrastructure such as road and rail alignment are given separately

S. nº	Purpose	Cost Items	Unit Rate	Area (Ha)	Nº of Locations	Frequency	Cost in Million INR
1	Cost of Contractors EMP for all planned EMP implementation measures	Action plan report	1				7,00
2	Cost of Capacity building- Training and Institutional strengthening	Training workshop	2				2,00
3	Solid waste management (sector wise)	Collection disposal system	LS				10,00
4	Storm water Management		LS				20,00
5	Marine Life Protection out of Oil Spill (Provision for scavenger boat)	One tugboat with booms and skimmer and dust exhausting equipment	LS				200,00
6	Cost of scavenger boast including manpower	Cost of boat	LS				2,00
7	Dust Sweeper		2				6,00
8	Air Pollution Control	2 water tankers for wetting of road surface and springing system	LS				4,00
9	Water and waste water treatment plants		LS				20,00
10	Battery of toilets with bimonthly maintenance provision 10		LS				10,00
11	Desilting and strengthen of Streams lumpsum 5		LS				2,00
						Subtotal	283,00
	Environmental Monitoring Cost for Constuction Period (30 months)						
12	Air quality monitoring at sensitive locations		3500		2	Once a week	0,84
13	Water quality monitoring at major water bodies		3000		2	Monthly once	0,18
14	Noise monitoring at sensitive locations		500		2	Monthly once	0,03
15	Soil quality monitoring at sensitive locations		2000		2	Once a year	0,01
16	Marine water quality and sediment and marine biology		LS			Monthly once	4,76
17	Shoreline changes		LS				2,00
						Subtotal	7,82
	Social Enchancement Costs						
18	Enhancement of water bodies (ponds along road & rail)	Pond	500000		2		1,00
19	Enhancement of religious structures (Temple)	Temple	500000		1		0,50
20	Cultural property rehabilitation cost for sacred grove	Sacred Grove	100000		1		0,10
						Subtotal	1,60
						Total	292,42

Table 59: Budget for Environmental Measures and Monitoring during **Construction Phase.**

S. Nº	Purpose	Cost Items	Unit Rate	Area (Ha)	Nº of Locations	Frequency	Cost in Million INR
1	O&M cost for solid waste management. Dustbins for waste	Dustbins for waste collection	50000				0,50
2	Dust suppression all along the alignment	Dust Sweeper/sprinking system	150000				1,20
3	Capacity building Training Workshop	Training Workshops	100000				1,00
4	Maintenance of booms and skimmer etc						7,00
5	Maintanance of Water and waste water treatment						2,00
6	Maintanance streams and storm water storage tank						1,20
7	Running cost EMC						
						Subtotal	12,90
	Environmental Monitoring Cost						
8	Air quality monitoring at sensitive locations		3500		2	Once a week	0,36
9	Water quality monitoring at major water bodies		3000		2	Monthly twice	0,14
10	Noise monitoring at sensitive locations		500		2	Monthly once	0,01
11	Soil quality monitoring at sensitive locations		2000		2	Once a year	0,01
12	Marine water quality and sediment and marine biology		LS			Monthly once	0,80
13	Shoreline changes						5,00
						Subtotal	6,33
	Enchancement Costs						
14	Enhancement of water bodies (ponds)	Pond	300000		2		0,60
15	Additional dug wells over and above rehabilitation R&R package	Dug Well	70000		2		0,14
16	Enhancement of pump houses	Pump House	30000		1		0,03
						Subtotal	0,77
						Total	20,00

Table 60: Budget for Environmental Measures and Monitoring during Operational **Phase.**

6.4.2. Budgetary estimates for CSR

CSR activities are also planned to achieve environmental standards:

A **preliminary budget** is included for the social measures proposed, **excluding land acquisition cost**, for port construction (reclamation) and implementation of the access road and railway corridors. The budgetary preliminary estimate for CSR measures for proposed port, road and railway alignment is **Rs 950 Million (95 Crores).**

Cost of CSR activities that include

- Water Supply Scheme for Enayam fishing Village
- Rehabilitation of livelihood loses. Creation of a skill development centre in Enayam
- Implementation of a new fishing harbour in Enayam (equipped with cold store, sanitation and loading and unloading and distribution facilities and integration with new fishing harbour (rehabilitation of the existing fishing harbour) in Colachel
- General CSR activities, as compensation measures, in sectors like fisheries, agriculture, tourism, common infrastructure facilities, educational & medical facilities, sanitation & wastewater treatment, etc (provision of funds for social enhancing measures)

Activity	Costs Heads -CSR	Cost (Rs Crores)
Water supply scheme for fishing village	Properly designed and estimated	5
New fish landing centre at Enayam	Properly designed and estimated	15
Balance Budget for CSR Activities in the project area.	General Measures	75
	Total	95

Table 61: Budget CSR.

7. CONCLUSIONS AND RECOMENDATIONS

The development of proposed Colachel Port at Tamil Nadu offers an efficient and cost effective supply chain/value proposition to the local importers and exporters. This could trigger a new set of opportunities as induced developments.

Initially, 4 alternatives were considered for the location of the port infrastructure. After a multicriteria analysis where the environmental and social factors played a key role together with the rest of the project components Enayam, was considered as the best rated alternative location, with the lowest impact, while the worst rated one, with the highest impact, is Colachel. Kanyakumari and Manavalakurichi obtained similar intermediate ratings.

The Enayam location has lower environmental impacts than the others with respect to dredging, cultural sites and its low impact on property due to its low population. Port expansion will not need a wide extra inland area since the land reclamation area will provide room for port facilities and industries.

Dedicated roadway and railway connectivity proposed for the Colachel-Enayam port would provide access to the major existing road and railway network which offers an efficient and cost effective supply chain/value proposition to the local importers and exporters in the State of Tamil Nadu. Employment opportunities to the local people would rise for skilled, semi-skilled and unskilled work force during the construction and operation phases

All this will accomplish one of the main aims of the proposed port project; which is to bring significant socio-economic benefits to the local people and also to the region as a whole, bringing significant benefits to local people and to the region as a whole and positive impact on the socioeconomic conditions of the project region and the whole Tamil Nadu State.

However the activities during the construction phase might have some other potential impacts on the socio-economic environment which includes dredging, reclamation, transportation of quarrying materials, construction of terminals and breakwater as well as establishment of labour camps. During the operation phase, the operation of terminals, marine traffic, road & rail traffic and establishment of labour/employee colony might have potential impact on the socio-economic environment of that region. However, as the port is planned to be developed entirely on the reclaimed land, no land acquisition is envisaged for the port development.

However, a total number of 427 properties would be directly affected by the implementation of the railway line and road connections. Apart from that, being an international harbour, the port would require additional basic infrastructure facilities, administrative buildings cruise and navy operations facilities, , warehouse, residential areas, truck parking areas . Hence, backup areas in the immediate vicinity will be required in the future for developing other further facilities.

As for the impact onto the current environmental conditions the port activities and their impacts on the environmental and social attributes during the development and operation phase have been discussed in detail.

It was concluded that most of the negative effects that may take place with the implementation of the project could be mitigated with the adoption of appropriate mitigation measures, both in construction and operational phase and the effective implementation of the proposed environmental management and monitoring programmes.
A preliminary environmental budget plan to address all environmental management requirements has been estimated, the budgetary provision required to achieve. Some of the key areas identified are the following:

- Environmental (terrestrial and marine) monitoring in both construction and operation phase Monitoring of Shoreline changes in Colachel-Enayam coast in both construction and operation phase
- Water & wastewater management. Solid waste management.,
- Groundwater development at Project Area. Focused water supply augmentation study in the 5 km study area. Storm water management and Rainwater harvesting is also planned
- Employment for solid waste management using Women Self Help Groups (SHG)-
- Fishermen who lost livelihood opportunities will be given preference in providing employment, scavenger boat operations. STP operators for the streams will be from those groups who lost Livelihood opportunities
- Rainwater harvesting, desiltation using silt traps, solid waste removal using waste trap, flow tank for spill over, collection tank, sump from where the water will be pumped to the various locations and also for the excess water to be drained to the sea by a naturally controlled mechanism.
- Sanitation facility at new fishing harbour for the entire fishing village Enayam. Bathing rooms.

The budgetary preliminary estimate for Environmental Management for proposed port, road and railway alignment during construction phase is Rs 292 Million (29 Crores) and the annual budgetary estimate during operational phase is Rs 20 Million

As for the social compensation and measures, the future Port Authority is encouraged to initiate many CSR activities for improving the way of living of people of Colachel-Enayam and other nearby villages in 2.0 km radii area in sectors like fisheries, agriculture, tourism, common infrastructure facilities, educational & medical facilities, sanitation & wastewater treatment, solid waste management, etc.CSR activities are also planned to achieve environmental standards:

A preliminary budget is included for the social measures proposed, excluding land acquisition cost, for port construction (reclamation) and implementation of the access road and railway corridors. The budgetary preliminary estimate for CSR measures for proposed port, road and railway alignment is Rs 950 Million (95 Crores).

Cost of CSR activities that include

- Water Supply Scheme for Enayam fishing Village
- Rehabilitation of livelihood loses. Creation of a skill development centre in Enayam
- Implementation of a new fishing harbour in Enayam (equipped with cold store, sanitation and loading and unloading and distribution facilities and integration with new fishing harbour (rehabilitation of the existing fishing harbour) in Colachel
- General CSR activities, as compensation measures, in sectors like fisheries, agriculture, tourism, common infrastructure facilities, educational & medical facilities, sanitation & wastewater treatment, etc (provision of funds for social enhancing measures)

Also to ensure the social feasibility of the project and to ensure the quality of the livelihood of the population in the project area, this preliminary Environmental Examination states that important studies and plans should be finished and approved before the project was operational. Final ESIA Report should address these important issues, and the conclusions of these studies and plans should be translated into conditions into the final Project Design.

It is then recommended that a set of Studies and Plans should be carried out before project implementation

- Risk Analysis

Addressing proposed project actions related risks associated with explosion, fire, or release of hazardous materials in the event of accident or a natural disaster with the construction and operation of the proposed port in terms of identifying the hazards and suggesting the suitable mitigation measures.

- Disaster Management Plan

A framework for Disaster Management Plan should be prepared to minimise damages in the event of a disaster. An On-Site Emergency Preparedness Plan and Off-Site Emergency Preparedness Plan must be broadly prepared to deal with emergencies and prevent disasters including an institutional framework with clear assignment of roles and responsibilities was broadly prepared with which location of Emergency Control Centre and Assembly Points to be identified.

- Spill Contingency Plan

An oil spill contingency plan for shall be prepared and approved by the Indian Coastguard. It would describe about the different organisation/ teams required and their responsibilities. It also covered training, inspection and drill schedule and equipment, etc. required effect function of contingency plan.

Finally, the proposed Port Project is a Category A Project as the proposed cargo handling capacity is ≥ 5 million tonnes per annum (TPA). Hence, Environmental Clearance from the Ministry of Environment and Forest (MoEF), Government of India will be required as given in rule 2(II) of Annex I of the "EIA Notification" of The Environment (Protection) Act, 1986.

In further project development phases, a full comprehensive Environmental Social Impact Assessment Study should be carried out as per the MoEF's EIA Guidance Manual for Ports and Harbour along with the International Finance Corporation's (IFC) Performance Standards 2006, Environmental, Health and Safety (EHS) Guidelines for Ports, Harbour and Terminals, and EHS Guidelines for Construction Materials Extraction for obtaining the Clearance from MoEF.

ANNEXURE 6:

TRAFFIC FLOW DATA

Distribution of Indian container traffic - Traffic in Mn TEU										
Port	Trans-shipment							Indian Coastal	Direct Dest-ination	Grand Total
	Singa-pore	Klang	Dubai	Colombo	Jebel Ali	Other Interna-tional Ports	Total			
Kolkata	215	76	-	108	-	11	410	39	-	449
Haldia	29	24	-	59	-	1	113	-	-	113
Parad i p	3	0	-	0	-	4	8	1	-	9
Visakhapatnam	40	14	-	30	4	141	229	27	6	262
Chennai	188	135	3	278	-	206	810	40	618	1,468
V.O. Chidambaranar	-	-	-	391	27	-	418	58	33	509
Cochin	10	4	-	142	30	18	204	114	29	347
New Mangalore	-	-	-	-	-	-	-	50	-	50
Mormugao	-	-	-	-	-	-	-	19	-	19
Mumbai	-	-	-	-	-	-	-	8	32	40
J.N.P.T.	3	1	-	3	9	32	47	59	4,055	4,161
KANDLA	-	-	-	-	0	1	1	29	-	30
Mundra	100	50	1	150	14	105	420	123	2,100	2,643
Other Minor Ports	39	18	0	13	12	43	126	71	653	850
Total	**627**	**322**	**4**	**1,175**	**96**	**561**	**2,786**	**638**	**7,526**	**10,950**

ANNEXURE 7:
FINANCIAL STATEMENTS

PROFIT & LOSS STATEMENT

All financials in the scenario without VGF

Financial year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Revenue	0.0	0.0	0.0	650.7	899.1	1,149.1	1,630.9	2,237.2	2,837.9	3,383.5	3,995.9	4,523.9	5,140.0	5,831.3	6,604.8	7,450.9
Operating Expenses	0.0	0.0	0.0	309.2	437.9	675.3	825.0	1,013.2	1,171.3	1,390.1	1,877.5	2,017.2	2,171.8	2,339.2	2,521.1	2,715.5
EBITDA	**0.0**	**0.0**	**0.0**	**341.4**	**461.2**	**473.8**	**805.8**	**1,224.0**	**1,666.7**	**1,993.3**	**2,118.3**	**2,506.7**	**2,968.2**	**3,492.0**	**4,083.7**	**4,735.4**
Depreciation	0.0	0.0	0.0	478.3	478.3	478.3	1,483.7	1,483.7	1,483.7	1,483.7	1,483.7	2,336.9	2,336.9	2,336.9	2,336.9	1,651.4
EBIT	**0.0**	**0.0**	**0.0**	**(136.9)**	**(17.1)**	**(4.6)**	**(677.8)**	**(259.6)**	**183.0**	**509.7**	**634.7**	**169.8**	**631.3**	**1,155.1**	**1,746.8**	**3,084.0**
Total Interest	0.0	0.0	0.0	551.4	503.4	455.5	1,196.6	1,183.4	1,112.1	979.9	847.7	1,508.6	1,307.4	1,106.3	905.1	727.9
PBT	**0.0**	**0.0**	**0.0**	**(688.2)**	**(520.5)**	**(460.0)**	**(1,874.5)**	**(1,443.0)**	**(929.2)**	**(470.3)**	**(213.1)**	**(1,338)**	**(676.2)**	**48.9**	**841.7**	**2,356.1**
Tax payable	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	320.6	660.8	1,002.3
PAT	**0.0**	**0.0**	**0.0**	**(688.2)**	**(520.5)**	**(460.0)**	**(1,874.5)**	**(1,443.0)**	**(929.2)**	**(470.3)**	**(213.1)**	**(1,338)**	**(676.2)**	**(271.8)**	**180.9**	**1,353.8**

Financial year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Revenue	8,356.6	9,363.9	10,359.8	10,928.6	11,529.8	12,163.2	12,831.2	13,535.7	14,279.1	15,063.1	15,889.6	16,762.0	17,683.3	18,654.4
Operating Expenses	2,912.6	3,125.4	3,355.6	3,604.4	3,873.7	4,186.6	4,528.2	4,901.6	5,308.9	5,747.3	6,226.6	6,748.7	7,318.5	7,941.5
EBITDA	**5,444.0**	**6,238.4**	**7,004.2**	**7,324.2**	**7,656.1**	**7,976.6**	**8,303.0**	**8,634.2**	**8,970.2**	**9,315.8**	**9,663.0**	**10,013.4**	**10,364.8**	**10,712.9**
	1,192.6	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4	503.4
Depreciation	**4,251.4**	**5,735.1**	**6,500.8**	**6,820.8**	**7,152.7**	**7,473.2**	**7,799.7**	**8,130.8**	**8,466.9**	**8,812.4**	**9,159.6**	**9,510.0**	**9,861.4**	**10,209.5**
EBIT	574.7	421.4	310.3	241.4	172.4	103.5	34.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3,676.8	**5,313.6**	**6,190.5**	**6,579.4**	**6,980.3**	**7,369.8**	**7,765.2**	**8,130.8**	**8,466.9**	**8,812.4**	**9,159.6**	**9,510.0**	**9,861.4**	**10,209.5**
Total Interest	1,345.8	1,710.9	2,045.4	2,208.8	2,371.6	2,526.8	2,680.7	2,821.8	2,950.5	3,080.4	3,209.2	3,337.6	3,465.1	3,590.5
PBT	**2,330.9**	**3,602.8**	**4,145.0**	**4,370.6**	**4,608.6**	**4,843.0**	**5,084.5**	**5,309.0**	**5,516.4**	**5,732.1**	**5,950.5**	**6,172.4**	**6,396.3**	**6,619.0**
	8,356.6	9,363.9	10,359.8	10,928.6	11,529.8	12,163.2	12,831.2	13,535.7	14,279.1	15,063.1	15,889.6	16,762.0	17,683.3	18,654.4
Tax payable	2,912.6	3,125.4	3,355.6	3,604.4	3,873.7	4,186.6	4,528.2	4,901.6	5,308.9	5,747.3	6,226.6	6,748.7	7,318.5	7,941.5
PAT	**5,444.0**	**6,238.4**	**7,004.2**	**7,324.2**	**7,656.1**	**7,976.6**	**8,303.0**	**8,634.2**	**8,970.2**	**9,315.8**	**9,663.0**	**10,013.4**	**10,364.8**	**10,712.9**

CASH FLOW STATEMENT

Financial year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EBITDA	0	0	0	341	461	474	806	1,224	1,667	1,993	2,118	2,507	2,968	3,492	4,084	4,735
Less: Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	321	661	1,002
Less: Capital Expenditure	1,177	2,237	3,162	1,329	2,955	4,552	1,327	1,393	1,100	2,480	5,878	0	0	0	0	0
Free cash flow to project	**(1,177)**	**(2,237)**	**(3,162)**	**(987)**	**(2,494)**	**(4,078)**	**(521)**	**(169)**	**567**	**(486)**	**(3,760)**	**2,507**	**2,968**	**3,171**	**3,423**	**3,733**

Financial year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
EBITDA	5,444	6,238	7,004	7,324	7,656	7,977	8,303	8,634	8,970	9,316	9,663	10,013	10,365	10,713
Less: Tax	1,346	1,711	2,045	2,209	2,372	2,527	2,681	2,822	2,950	3,080	3,209	3,338	3,465	3,590
Less: Capital Expenditure	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free cash flow to project	**4,098**	**4,528**	**4,959**	**5,115**	**5,284**	**5,450**	**5,622**	**5,812**	**6,020**	**6,235**	**6,454**	**6,676**	**6,900**	**7,122**

Financial year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Free cash flow to project	(1,177)	(2,237)	(3,162)	(987)	(2,494)	(4,078)	(521)	(169)	567	(486)	(3,760)	2,507	2,968	3,171	3,423	3,733
Add: Debt	824	1,566	2,213	930	2,069	3,186	929	975	770	1,736	4,115	0	0	0	0	0
Less: Interest	0	0	0	551	503	455	1,197	1,183	1,112	980	848	1,509	1,307	1,106	905	728
Less: Repayment of Debt	0	0	0	384	384	384	1,058	1,058	1,058	1,058	1,058	1,609	1,609	1,609	1,609	1,226
Add: VGF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free cash flow to equity	**(353)**	**(671)**	**(948)**	**(992)**	**(1,312)**	**(1,731)**	**(1,846)**	**(1,435)**	**(833)**	**(788)**	**(1,550)**	**(611)**	**51**	**456**	**908**	**1,779**

Financial year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Free cash flow to project	4,098.2	4,527.6	4,958.7	5,115.4	5,284.4	5,449.8	5,622.3	5,812.4	6,019.8	6,235.4	6,453.8	6,675.8	6,899.7	7,122.4
Add: Debt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Less: Interest	574.7	421.4	310.3	241.4	172.4	103.5	34.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Less: Repayment of Debt	1,225.8	1,225.8	551.7	551.7	551.7	551.7	551.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Add: VGF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Free cash flow to equity	**2,297.8**	**2,880.3**	**4,096.7**	**4,322.3**	**4,560.3**	**4,794.6**	**5,036.1**	**5,812.4**	**6,019.8**	**6,235.4**	**6,453.8**	**6,675.8**	**6,899.7**	**7,122.4**