

# **EXECUTIVE SUMMARY**

**of**

**E.I.A. Study Report prepared by National  
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**for**

**Development of projects under PPA  
Comprehensive Master Plan for  
Implementation in Next 10 years**



**PARADIP PORT AUTHORITY**

## EXECUTIVE SUMMARY

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### Introduction

Paradip Port, situated on the eastern coast of India in Odisha, was commissioned in 1966 and has steadily evolved into one of the country's most significant maritime gateways. Strategically located approximately 210 nautical miles south of Kolkata and 260 nautical miles north of Visakhapatnam, the port offers seamless connectivity to global shipping routes in the Bay of Bengal, extending to Southeast Asia and beyond. Over the decades, Paradip Port has transformed from a modest regional harbor into a deep-water port handling a diverse portfolio of bulk, liquid, break-bulk and container cargo. Its cargo profile predominantly includes iron ore, coal, crude oil, petroleum products and fertilizers, all of which are critical for India's steel, mining, energy, and agriculture sectors. The port has also supported petrochemical and fertiliser complexes in India, thereby catalyzing industrial as well as economic development in India. With modernization measures such as mechanized cargo handling systems, handling of deep-draft vessels, and upgraded storage yards, Paradip Port has positioned itself as a core component of India's Sagarmala Initiative and National Maritime Vision 2047. However, rising cargo demand, estimated to reach 450 MMTPA by 2047, necessitates further augmentation of infrastructure. The Port Development Plan emphasizes expansion of berthing facilities, modernization of operations, strengthening of multimodal connectivity, and adoption of sustainable and green port practices.

### *Location, Nature, and Size of the Project*

Paradip Port is located at 20° 15' 55.44" N and 86° 40' 34.62" E, along Odisha's coastline, and covers approximately 2,500 hectares. The site is strategically positioned to serve the mineral-rich hinterland, while also connecting to agricultural and industrial hubs in India. Connectivity remains a key strength of Paradip Port. It is linked by National Highway 53 to the mining and industrial hinterlands and State Highway 12 to major urban centers such as Bhubaneswar and Cuttack. Rail connectivity is ensured through the East Coast Railway's broad-gauge network, while inland waterway connectivity via the Mahanadi River and National Waterway-5 provides an additional sustainable transport option. The proposed expansion project, with an investment of approximately ₹6,935 crore, includes the construction of new berths and terminals, modernization of cargo handling facilities with conveyor systems, as well as automated cranes. Backup areas, green ammonia handling, alongside adoption of green initiatives such as renewable energy integration. Post-expansion, Paradip Port's operational capacity will increase from 160 MMTPA in 2025 to 250 MMTPA by 2030 and 500+ MMTPA by 2047.

### *Applicability of Environmental Clearances*

The proposed expansion falls under Category A of the EIA Notification, 2006 (as amended), under the Environment (Protection) Act, 1986, and therefore requires prior Environmental Clearance from the Ministry of Environment, Forest and Climate Change

(MoEF&CC). Since the project involves marine infrastructure and coastal land use, it also requires compliance with the Coastal Regulation Zone (CRZ) Notification. Additionally, approvals from the Odisha Coastal Zone Management Authority (OCZMA), Government of Odisha. These multi-tier environmental and statutory clearances ensure compliance with both national and international maritime standards.

## Project Description

### *Need for the Project*

The expansion of Paradip Port is necessitated by growing capacity constraints and increasing trade volumes. Current infrastructure is nearing saturation, and without expansion, the port will face congestion, longer turnaround times, and reduced competitiveness. Cargo traffic is projected to rise from 150.41 MMTPA in 2024–25 to 250 MMTPA by 2030, and 450 MMTPA by 2047. Industrial growth in eastern India, particularly in steel, power, fertiliser, and petrochemical sectors, further underscores the need for efficient port logistics. Strategically, Paradip serves as India’s maritime hub, supporting both exports such as iron ore, steel, and agricultural products and imports such as coal, crude oil, fertilisers, and chemicals. Moreover, the port will play a pivotal role in India’s green energy transition, acting as a hub for green hydrogen, green ammonia, and LNG-based fuels. In essence, the expansion is essential not only for accommodating trade growth but also for aligning the port with sustainable and future-ready operations.

## Proposed Development

The proposed expansion of the port incorporates a wide range of modern and sustainable facilities aimed at enhancing capacity and efficiency.

### *New proposed Projects:*

Sl. No.	Proposed Development	Capacity
1	Two nos. of berths in North Dock Complex as NDC-3 & NDC-4	24 MTPA
2	Development of Green Hydrogen/ Ammonia Berth	4 MTPA
3	Development of SQ-II Berth (Short Arm near IOB)	7 MTPA
4	Development of South Container Berth (SCB)	2 Lakh TEU per Annum/ 3 MTPA
5	Development of NQ-III Berth (Short Arm in North Dock Complex)	2.5 MTPA
6	Extension of North Oil Jetty	1.5 MTPA
7	Development of South Western Dock	25 MTPA
<b>Total</b>		<b>67 MTPA</b>

### *1. NDC-3 & NDC-4 (North Dock Complex-3 & 4) Berths*

The NDC-3 & 4 Berths are proposed to be constructed in the North Dock Complex (opposite to KICTPPL Coal Import Berth and JSWPTPL Iron Ore Export Berth respectively). The berths are of 330 m length each and 12 MTPA capacities each to handle dry bulk cargo.

### *2. Green Hydrogen/Ammonia Berth*

The Green Hydrogen/Ammonia Berth is proposed to be constructed adjacent to the Southern Dock Complex in compliance with Green Port initiatives & promotion of Green Energy. The berth is of 279 m length and is of 4 MTPA capacity to handle Green Hydrogen/Ammonia and other liquid cargo.

### *3. South Container Berth*

The South Container Berth is proposed to be constructed in the Southern Dock Complex adjacent to the PICTPL Clean Cargo Terminal. The berth is of 270 m length and has capacity of 2 Lakh TEU per Annum (3 MTPA) to handle Containers and clean cargo.

### *4. SQ-II (South Quay-II) Berth*

The SQ-II Berth is proposed to be constructed in the short arm connecting existing IOB and JSWPTL Iron Ore Berth. The berth is of 260 m length and is of 7 MTPA capacity to handle dry bulk cargo.

### *5. NQ-III (North Quay-III) Berth*

The NQ-III Berth is proposed to be constructed in the North Dock Complex (short arm connecting KICTPPL Coal Import Berth and NDC-3 Berth). The berth is of 270 m length and is of 2.5 MTPA capacity to handle dry bulk cargo.

### *6. Extension of North Oil Jetty (NOJ)*

The existing North Oil Jetty (NOJ) is proposed to be extended towards the North Dock Complex. The NOJ extension will be for 120 m length and is of 1.5 MTPA capacity to handle liquid cargo.

### *7. South Western Dock*

The South Western Dock is proposed to be constructed adjacent to the Western Dock. The overall dock in its two opposite arms and the connecting short arm will have 1400 m berth length and will be of 25 MTPA capacity to handle dry bulk and break bulk cargo.

All the above proposed berths will be fully mechanized berths and will require ship unloaders, stackers and reclaimers along with development of stackyards and other ancillary facilities for minimizing handling times and optimizing material flow by mechanical means.

The capital dredging volume for the project is projected at approximately 4.5 million cubic meters (Mm<sup>3</sup>). The South Western Dock requires the removal of 3.5-4.5 Mm<sup>3</sup>, while the North Dock Complex will involve an additional 0.55 Mm<sup>3</sup> of dredging. The dredging process will utilize advanced equipment, including cutter suction dredgers and trailing suction hopper dredgers, to ensure precision and efficiency. A key aspect of the dredging plan is the sustainable use of dredged materials. Suitable dredged material will be repurposed for land reclamation, stabilizing stockyards, and creating backup operational areas. These measures, combined with compliance with environmental norms ensure that dredging activities contribute to both the port's development and shore nourishment. It is anticipated that some of the dredged material will also be dumped offshore at designated dumping locations.

**Infrastructure Expansion:** The construction of new berths, including specialized ones for handling clean cargo, green hydrogen, and ammonia, will increase the port's throughput and diversify its service offerings. This will enable Paradip Port to accommodate a wide range of cargo types and cater to evolving industrial needs.

**Upgrading Existing Facilities:** Existing infrastructure like the Iron Ore Berth will be modernized and expanded to enhance cargo handling capacity, improve operational efficiency, and meet higher traffic demands.

**Sustainability Initiatives:** In line with global environmental goals, the project will incorporate sustainable and eco-friendly technologies to minimize the port's ecological footprint. These initiatives will include energy-efficient systems, waste management solutions, and measures to protect marine biodiversity, ensuring the long-term environmental sustainability of the port. The proposal envisions transforming Paradip Port into a global maritime hub, capable of handling various cargo types, including green hydrogen and green ammonia. With increased capacity and improved infrastructure, the port aims to drive India's economic growth, support industrial development, and boost international trade.

### *Present Layout of Paradip Port*

Paradip Port Authority has well-developed infrastructure to facilitate efficient cargo handling and logistics. Here is a brief overview of each component:

- **Mechanised Coal Handling Plant:** This facility automates unloading, stacking, reclaiming, and loading of coal onto ships for sea transport, enhancing efficiency and reducing turnaround times.
- **Iron Ore Handling Plant:** Specialized equipment for the bulk handling of iron ore, ensuring smooth operations and minimizing losses during transit.
- **General Cargo Berths:** Designed to accommodate a variety of cargo types, these support diverse shipping needs and contribute to the port's versatility.

- **Oil Jetty:** Dedicated facilities for the handling of liquid cargo, particularly petroleum products, equipped with specialized infrastructure for safety and efficiency.
- **Captive Berths:** These berths are typically reserved for specific industries or companies, allowing them to efficiently manage their cargo operations.
- **BOT Berths:** Build-Operate-Transfer berths are developed through private partnerships, improving infrastructure and service quality while enhancing operational capabilities
- **Container Handling:** This area is equipped for loading and unloading containers, featuring advanced systems to manage containerized cargo efficiently.
- **Cargo Handling Equipment:** A range of machinery, including cranes, conveyors, and forklifts, supports various cargo types, ensuring swift and effective handling.
- **Port Railways:** An integrated railway system connects the port to the hinterland, facilitating the movement of goods and reducing transportation costs.
- **Storage:** Adequate storage facilities, including warehouses and open yards, allow for the temporary holding of cargo, ensuring smooth operations and inventory management.

### **Existing Berths and Facilities**

The Port of Paradip is an artificial lagoon-type harbor, safeguarded by two rubble mound breakwaters and connected to deep waters through a dredged channel. Currently, it has 18 berths, distributed as follows:

**Northern Side:** The Eastern Dock, Central Dock and North Dock Complex house 16 berths.

**Southern Side:** The South Oil Jetty (SOJ) and the PICTPL Multipurpose Clean Cargo/ Container Berth are operational.

Additionally, the port features three Single Point Moorings (SPMs) dedicated to Indian Oil Corporation Ltd. (IOCL). Details of all the berths at Paradip Port are described below and the same as presented in the Table.

Berth No.	Berth Name	Nature of Cargo Handled
1	North Oil jetty	P.O.L
2	New Iron Ore Berth	Iron ore
3	New Coal Import Berth	Coal
4	Iron Ore berth	Iron Ore
5	Coal Berth - 1	Coal

Berth No.	Berth Name	Nature of Cargo Handled
6	Coal Berth - 2	
7	East Quay - 1	Coal
8	East Quay - 2	
9	East Quay - 3	
10	Southern Quay	Multi Cargo
11	Central Quay - 1	Multi Cargo
12	Central Quay - 2	
13	Central Quay - 3	Dry Bulk Cargo
14	Multipurpose Berth	Dry Bulk Cargo
15	Fertilizer Berth - 1	Fertilizer Raw Materials
16	Fertilizer Berth - 2	Fertilizer Raw Materials
17	PICT-Multi-Purpose Berth	Clean cargo including containers
18	South Oil Jetty	P.O.L / LPG

Besides the above, Paradip Port has 3 nos. of SPMs within its Port limit waters which were constructed and presently operated by IOCL for crude oil imports.

### Analysis of Alternatives

A comparative study of alternatives was carried out to select a project design that reduces environmental impacts while improving operational efficiency. For the site alternatives, different expansion areas within the port were assessed. The selected site was preferred because it makes use of existing port facilities, avoids major displacement of people, and requires less environmental impacts. In terms of berth layout, options such as linear berths, finger jetties, and parallel alignment were considered. The parallel alignment was chosen since it reduces wave disturbance, lowers dredging needs, and allows safer vessel movement. For cargo handling, bulk cargo berths were aligned in a north–south direction to reduce siltation, while liquid cargo facilities, such as those for green ammonia and hydrogen, were planned with mooring dolphins to limit ecological disturbance. Overall, the chosen alternatives strike a balance between technical feasibility, economic benefits, and environmental protection, while ensuring flexibility to meet future trade demands.

### Description of Environment

The baseline environmental monitoring study establishes the prevailing environmental conditions in and around the Paradip Port project area, covering a 10 km radius. This assessment is a critical component of the Environmental Impact Assessment (EIA), as it provides the benchmark against which future project-related impacts can be predicted and evaluated. The study, conducted in accordance with ToR given by EAC-MoEF&CC and CPCB guidelines, integrates both primary field data and secondary published

information to build a robust environmental profile. Key components assessed include meteorology, air quality, water resources, noise, soil, land use, ecology, and socio-economic features.

### *Meteorology and Climate*

Paradip Port lies within the Tropical Wet and Dry (Aw) climate zone, characterized by hot summers, mild winters, and a distinct monsoon season. Average annual rainfall exceeds 1,500 mm, with considerable variability influencing local hydrology and pollutant dispersion. Temperatures generally range from 25°C in winter to 35°C in summer, while relative humidity fluctuates between 45% and 81%. Wind data from 2019–2024 show consistent monsoonal influence, with prevailing directions shaping air circulation and pollution dispersion across the study area. Importantly, the region is highly vulnerable to cyclonic disturbances originating in the Bay of Bengal. The impacts of the 1999 Super Cyclone and Cyclone Fani (2019) underscore the necessity of disaster-resilient infrastructure for future port activities.

### *Air Environment*

Ambient air quality monitoring was carried out at thirteen locations, covering inside port premises and nearby settlements. Parameters included PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, NH<sub>3</sub>, CO, O<sub>3</sub>, benzene, benzo(a)pyrene, and heavy metals (Pb, Ni, As). The results reveal that particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) occasionally exceeded NAAQS standards, particularly in pre-monsoon months at traffic-heavy and cargo-handling zones, highlighting the influence of dust and vehicular emissions. Post-monsoon measurements showed improvement due to rain-induced washout. Other gaseous pollutants such as SO<sub>2</sub>, NO<sub>2</sub>, CO, and O<sub>3</sub> remained well within permissible limits, though slightly elevated values were detected inside the port due to industrial activity. Heavy metals were consistently within safe thresholds. Overall, the air environment is satisfactory, though displaying localized challenges with particulate matter, emphasizing the need for targeted dust suppression and emissions control.

### *Water Environment*

Water quality monitoring was conducted across 56 stations, including 15 surface water, 16 groundwater, 25 marine and riverine stations, and sediment sampling sites. Results demonstrate that most parameters comply with CPCB standards. Surface and marine waters show balanced pH and adequate dissolved oxygen, indicating healthy ecological productivity and suitability for aquatic life. Groundwater is generally fit for drinking and domestic use; however, a few locations revealed elevated iron concentrations and evidence of minor salinity intrusion, reflecting coastal aquifer vulnerability. Heavy metals and toxic substances were absent or within permissible limits, indicating limited anthropogenic contamination at baseline. These findings suggest functional aquatic ecosystems but also highlight the importance of managing salinity ingress and monitoring industrial effluent to prevent long-term deterioration.

### *Noise and Vibration Environment*

Noise monitoring across 35 locations representing residential, commercial, industrial, and silence zones indicates varied exposure levels. Residential areas recorded 50.5–58.9 dB during daytime, mostly within CPCB norms (55 dB). Commercial zones registered slightly higher levels of 60.6–70.8 dB, attributed to market activity and traffic, but still generally within permissible limits (65 dB). Industrial and port operational areas exhibited the highest levels, ranging from 70.1–79.2 dB, occasionally breaching the 75 dB limit during cargo handling. Nighttime noise was lower overall but remained elevated near port gates and highways. While the majority of zones comply with standards, the findings underline the need for continuous noise monitoring and local mitigation measures such as acoustic barriers and scheduling restrictions in port-intensive areas.

### *Soil Environment*

Soil and sediment sampling from 40 locations (12 terrestrial, 28 aquatic) revealed predominantly sandy-loam textures with neutral to slightly alkaline pH. Organic matter content and macronutrient levels were moderate, indicating soils that support agriculture and plantation activities. Heavy metal concentrations remained within permissible ranges, with no evidence of contamination from industrial or port activities. These results confirm the absence of legacy pollution in terrestrial soils and indicate the potential for continued agricultural productivity in surrounding areas.

### *Land Use and Land Cover (LULC)*

A decadal satellite imagery analysis (2015–2024) shows notable land use changes. Conversely, mangrove cover increased by 5.46 km<sup>2</sup>, reflecting successful afforestation and coastal protection programs. Industrial land expanded by 2.95 km<sup>2</sup>, and the port footprint grew by 1.38 km<sup>2</sup>, consistent with development trends. Waterlogged zones were slightly reduced due to reclamation activities. Agricultural land was partially reduced by 8.76 km<sup>2</sup>, generally converted to industrial and aquaculture purposes. These dynamics reveal an ongoing transition toward industrialization, balanced by ecological restoration in the form of mangrove regeneration.

### *Ecological Environment*

Ecological surveys demonstrate healthy marine biodiversity with robust plankton, benthic organisms, and fish populations, indicative of productive coastal waters. Terrestrial ecosystems are dominated by cultivated fields, plantations, and scrubland, supporting moderate avifaunal diversity, including both resident and migratory species. The absence of ecologically critical or protected species suggests that port expansion, if managed responsibly, will not significantly disrupt biodiversity. However, continued monitoring and habitat conservation remain essential safeguards.

### *Socio-Economic Environment*

The socio-economic assessment within the 10 km buffer zone reveals a mixed semi-urban and rural profile. Agriculture, fishing, small-scale trade, and port-linked industries

are the primary sources of livelihood. Literacy levels are moderate to high, reflecting the presence of educational facilities, though rural peripheries still face infrastructural gaps. Access to drinking water, electricity, healthcare, and sanitation is available in most settlements but requires strengthening to match urban standards. Paradip Port is the principal driver of local employment and economic activity, and its expansion is expected to generate additional livelihood opportunities, enhance infrastructure, and improve regional socio-economic resilience.

### **Anticipated Environmental Impacts and Mitigation Measures**

The Environmental Impact Assessment (EIA) of the Paradip Port capacity expansion project has been carried out in compliance with MoEF&CC and CPCB regulations. The approach integrates baseline environmental conditions, predictive modeling, and established industry best practices to forecast likely changes due to project activities and to define suitable management measures. The anticipated impacts and mitigation measures are discussed below for each environmental component.

#### *Air Environment*

During the construction phase, activities such as land reclamation, excavation, material handling, vehicular traffic, and the use of heavy machinery are expected to temporarily elevate dust and particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) levels, particularly inside the port area. In the operational phase, air emissions will mainly arise from cargo handling of bulk commodities such as coal, fertilizer, and ores, in addition to ship exhaust emissions containing NO<sub>2</sub>, SO<sub>2</sub>, CO<sub>2</sub>, and hydrocarbons. Increased vehicular traffic will further contribute to localized air quality deterioration near port gates, cargo berths, and transportation corridors. While strong coastal winds will aid dispersion of pollutants, episodic high concentrations may still occur under calm and dry conditions.

To mitigate these impacts, dust suppression systems such as water sprinkling, fogging, and mechanized sweeping will be implemented in cargo yards and construction areas. Covered conveyors and enclosed storage systems will be provided for dusty cargo to reduce fugitive emissions. Vehicles and ships operating within the port will be required to comply with emission standards, and the use of low-sulphur fuels will be encouraged. A greenbelt covering at least 33% of the port boundary will be developed to act as a natural barrier against dust and gaseous pollutants. Continuous Ambient Air Quality Monitoring (CAAQM) stations will be established near sensitive receptors to ensure compliance with NAAQS.

#### *Noise and Vibration Environment*

Construction activities such as pile driving, crane operation, concrete batching, and transportation are anticipated to cause temporary increases in noise and vibration levels, which may occasionally exceed CPCB norms in adjacent settlements. During operations, major sources of noise will include cargo handling equipment, ship engines, conveyor belts, and truck movement. These can cause chronic disturbance, especially in residential and commercial areas near port gates.

Mitigation measures include the use of low-noise/vibrant machinery fitted with silencers and mufflers, and acoustic enclosures for DG sets and other high-noise equipment. Greenbelts and noise barriers will be developed along the port periphery and highways to absorb and deflect noise. Noisy construction activities near habitation will be restricted to daytime hours. In addition, periodic noise mapping will be conducted to identify hotspots and implement corrective measures where necessary.

### *Water Environment*

Construction activities may lead to runoff carrying sediments and suspended solids, which could increase turbidity in nearby creeks and estuarine waters. Domestic wastewater generated from labor camps poses risks of contamination if not properly treated. During operation, ballast water discharge, accidental oil leaks, and cargo spillage (especially from coal and fertilizer dust) may impact marine water quality and aquatic organisms.

Mitigation measures include construction of additional sewage treatment plants (STPs) to treat wastewater from labor camps and port utilities. Sediment traps and settling ponds will be provided to control siltation during construction. The port will strictly adhere to MARPOL conventions for ballast water and bilge discharges. An emergency oil spill response system will be deployed, including booms, skimmers, and trained personnel. Regular monitoring of marine water quality and sediments will be carried out to ensure early detection of any adverse trends.

### *Soil and Land Environment*

Land preparation, excavation, and reclamation activities are expected to result in topsoil loss, compaction, and erosion. Accidental spillage of oil, fuel, and hazardous cargo could lead to localized soil contamination. Additionally, the conversion of agricultural and open land for port expansion will reduce the area available for cultivation.

Mitigation measures include careful stripping and preservation of topsoil for reuse in landscaping and greenbelt development. Fuel and oil storage areas will be equipped with impermeable flooring and containment bunds to prevent seepage into soil. Erosion control measures such as slope stabilization, turfing, and geotextile application will be adopted. Soil quality monitoring will also be carried out to detect contamination and initiate remedial measures in time.

### *Solid Waste and Hazardous Waste Management (SHW)*

The potential environmental impacts of the port can be effectively managed through comprehensive mitigation plans and eco-friendly practices. Proper handling of hazardous chemicals, efficient waste management, and enhancing local biodiversity through expanded green cover are essential to minimizing environmental harm. Construction Phase: The primary impact is the generation of Construction and Demolition (C&D) waste. Mitigation measures include proper segregation, recycling, and safe disposal in accordance with relevant regulations.

Operational Phase: The project anticipates increased waste generation due to urbanization and industrial expansion. To mitigate this, an Integrated Sustainable Waste Management (ISWM) plan will be implemented. This plan focuses on the "3R" concept (Reduce, Reuse, and Recycle/Return) and converting non-recyclable waste into energy using Material Recovery Facilities (MRF) and Waste-to-Energy (WTE) plants. The plan also includes measures to prevent marine pollution from ships in line with the MARPOL Convention.

### *Ecology and Biodiversity*

The ecology is particularly sensitive to project activities. Dredging and land reclamation can disturb benthic habitats, increase turbidity, and reduce light penetration in the water column, thereby affecting plankton productivity and benthic fauna. Oil spills and chemical leaks could disrupt plankton balance, fish spawning grounds, and benthic communities. The increase in vessel traffic also raises the risk of invasive alien species introduction through ballast water.

Mitigation measures include the adoption of environmentally sound dredging practices with disposal of dredged material at designated offshore sites. Dredging will be scheduled to avoid fish spawning seasons. Ballast water management systems will be implemented in accordance with IMO regulations to prevent invasive species introduction. Continuous monitoring of plankton, benthic fauna, and fish diversity will be undertaken to track ecological conservation.

### *Terrestrial Ecology*

The terrestrial ecology of the area will be affected primarily by the loss of limited vegetation during site clearance. Noise, artificial lighting, and human activity could disturb terrestrial fauna in adjacent buffer areas.

Mitigation measures include the development of a large-scale greenbelt within the port using native and salt-tolerant species to restore habitat value. Compensatory afforestation will be undertaken in degraded lands to offset vegetation loss. Wildlife awareness programs will be conducted, and activities near ecologically sensitive patches will be regulated to minimize disturbance.

### *Socio-Economic Environment*

The project will have significant socio-economic implications. Positive impacts include large-scale employment generation, stimulation of local and regional economies, and infrastructure improvements. However, adverse impacts could arise from increased dust, noise, and traffic congestion, as well as additional pressure on local civic amenities. Heavy truck and cargo traffic may disrupt normal life in nearby villages if traffic management is not properly planned.

To address these issues, priority will be given to local employment during both construction and operation phases, thereby boosting community participation and economic inclusion. Corporate Social Responsibility (CSR) initiatives will focus on

healthcare, sanitation, and education. Dedicated port roads, truck terminals, and traffic management systems will be developed to minimize congestion and ensure safe movement of goods and vehicles.

### *Occupational Health and Safety*

Workers engaged in construction, cargo handling, and dredging are exposed to risks such as accidents, noise-induced hearing loss, heat stress, and exposure to chemicals.

To mitigate these risks, the port will enforce mandatory use of personal protective equipment (PPE) for all workers. Regular safety training, mock drills, and emergency preparedness exercises will be carried out for scenarios including fire, oil spills, and chemical leaks. Health surveillance programs, including periodic medical check-ups, will be conducted for workers. Compliance with relevant safety regulations, such as the Factories Act, Dock Workers (Safety, Health & Welfare) Rules, and OISD standards, will be strictly ensured.

### **Environmental Monitoring Program**

To ensure compliance with statutory requirements and to promote continuous environmental improvement, a comprehensive and integrated Environmental Monitoring Program has been designed for the Paradip Port Capacity Expansion Project. The program aligns with MoEF&CC and CPCB guidelines and covers all key environmental components, enabling systematic evaluation of project-related impacts during both the construction and operational phases.

### *Air Quality Monitoring*

Ambient air quality monitoring will be carried out at multiple locations, including port premises and nearby sensitive receptors such as residential areas and schools. Parameters to be monitored include PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, CO, and volatile organic compounds (VOCs). In addition, Continuous Ambient Air Quality Monitoring Stations (CAAQMS) and Online Continuous Emission Monitoring Systems (OCEMS) will be installed and directly linked to the CPCB and OSPCB servers to ensure transparency and regulatory oversight. These systems will provide real-time data on air quality and allow rapid response in case of exceedances, ensuring compliance with National Ambient Air Quality Standards (NAAQS).

### *Water Quality Monitoring*

Surface water, groundwater, and marine waters will be monitored at representative locations for parameters such as pH, BOD, COD, nutrients, hydrocarbons, and heavy metals. Seasonal monitoring will include the assessment of plankton populations and fish health to evaluate impacts on aquatic ecology. Special attention will be given to the detection of hydrocarbons and heavy metals in marine waters, considering the risks of cargo spillage and increased vessel traffic. The results will help identify early signs of contamination and guide corrective action to safeguard freshwater and marine ecosystems.

### *Noise Monitoring*

Regular noise monitoring will be undertaken at sensitive receptors such as residential areas, hospitals, educational institutions, and port gates. Ambient noise levels will be measured in both daytime and nighttime conditions, ensuring compliance with CPCB standards. Noise mapping will be periodically conducted to detect hotspots, especially in areas affected by truck movement, cargo handling equipment, and ship operations. The data will inform the design and implementation of noise mitigation measures such as barriers and greenbelts.

### *Solid Waste and Hazardous Waste Management (SHW)*

The project will also conduct periodic monitoring to ensure continuous advancements in waste management infrastructure and practices to meet the challenges of increasing waste generation. The overall waste management plan is designed to be compliant with the Solid Waste Management Rules, 2016, and Plastic Waste Management Rules, 2022, ensuring adherence to established environmental standards. During the construction phase, monthly inspections of waste storage and disposal sites will be conducted to ensure proper segregation, recycling, and disposal.

A structured waste management plan will handle both solid and hazardous waste. During construction, an estimated 15–20 tons of solid waste per day will be collected, segregated, and transported to approved disposal sites. During operation, waste generation will be reduced to 10–12 tons per day with the adoption of recycling and reuse measures. Hazardous waste, such as 50–70 KL/year of used oil, chemical sludge, and oily residues, will be managed as per the Hazardous Waste Management Rules. The plan targets a minimum of 30% reuse and recycling of non-hazardous waste. Waste collection bins will be installed every 100 meters in high-activity areas, and scheduled waste audits will be conducted quarterly.

### *Soil Quality Monitoring*

Soil samples will be tested periodically to monitor heavy metals, hydrocarbons, pH, organic content, and nutrient balance. Monitoring will focus on areas with fuel storage, cargo yards, and potential spill-prone zones. The objective is to prevent long-term contamination of soil resources and to ensure that agricultural productivity in surrounding areas remains unaffected.

### *Ecological Monitoring*

The ecological monitoring program will include periodic surveys of fish catch, plankton diversity, benthic organisms, and mangrove health. Given the ecological sensitivity of coastal and estuarine ecosystems, this program will provide early-warning indicators of biodiversity stress. Mangrove monitoring, in particular, will track the effectiveness of compensatory afforestation and coastal protection efforts, while fish catch surveys will assess any impacts of dredging, vessel movement, and cargo operations on fisheries resources.

### *Socio-Economic Monitoring*

Socio-economic surveys will be conducted to evaluate the impacts of the project on employment, income generation, health services, and community infrastructure. The monitoring will also assess the effectiveness of Corporate Social Responsibility (CSR) initiatives in areas such as healthcare, sanitation, education, and skill development. This ensures that the benefits of port expansion are equitably shared with local communities, while also tracking potential adverse impacts such as traffic congestion or increased pressure on civic amenities.

### *Environmental Framework for Monitoring*

A dedicated Environmental Management Cell (EMC) will oversee the implementation of the monitoring program. The EMC will be supported by a fully equipped Environmental Laboratory, capable of conducting real-time analyses of air, water, soil, and biological samples. This will strengthen the capacity for timely environmental decision-making and compliance reporting. Six-monthly compliance reports will be submitted to the MoEF&CC and OSPCB, while annual third-party audits will ensure independent verification of environmental performance.

### *Budgetary Provisions and Long-Term Commitment*

The total project cost is estimated at Rs. 6,935 crore, out of which Rs. 25 crore has been earmarked for environmental monitoring during the construction phase, and Rs. 45 crore annually for the operational phase. This substantial financial commitment demonstrates the project's prioritization of environmental safeguards. The monitoring budget also covers risk assessment, disaster management planning, solid waste management, biodiversity conservation, and socio-economic upliftment measures such as improved health facilities, drainage systems, gender mainstreaming, and vocational training.

### **Additional Studies & Environmental Management Plan**

The additional studies undertaken for the Paradip Port expansion project provide a comprehensive evaluation of hydrodynamic, meteorological, environmental, and safety parameters essential for its sustainable development. These studies include hydrodynamic modelling, dredging impact analysis, tidal and wave characterisation, water level and current behaviour assessments, and the development of risk, safety, and environmental management frameworks. Together, they form a critical foundation for ensuring safe navigation, efficient port operations, and minimal ecological impact during and after the expansion process.

### *Hydrodynamic Modelling and Meteorological Analysis*

The hydrodynamic and meteorological studies focused on understanding the influence of wind, waves, and tides in the Paradip Port region throughout 2024. Annual wind analysis revealed an average speed of 4.6 m/s with a peak of 14.35 m/s recorded in October, during the northeast monsoon season. The predominant wind directions were

from the southwest between March and August, shifting to the northeast during the post-monsoon period. This seasonal variability directly impacts wave formation and nearshore current behaviour. Significant wave heights ranged between 0.4 and 3.7 metres, with the highest waves occurring in July and October, particularly in the southwest direction. Calm conditions, with wave heights below 0.44 metres, accounted for less than three percent of the year, indicating a generally moderate sea state. The tidal regime was classified as semi-diurnal, with an annual range between 0.33 and 2.96 metres. Spring tides during April and October reached up to 2.8 metres, while neap tides during July and December recorded approximately 1.0 metre. Residual water levels varied seasonally, with noticeable increases during the monsoon period attributed to storm surges and river discharge.

### *Dredging and Sediment Disposal Assessment*

Dredging is an essential component of the port expansion, and this study evaluated the suitability of four proposed disposal sites situated north of the navigational channel, with depths ranging from 10 to 19 metres. Integrated numerical modelling was conducted using hydrodynamic, spectral wave, transport, and mud transport models to simulate the dispersion and deposition of dredged sediments. The modelling applied by simulation at a concentration of 150 kg/m<sup>3</sup>, revealing that sediment concentrations ranged between 0.2 and 1.5 kg/m<sup>3</sup>, with the highest retention near the river mouth areas. Offshore disposal sites at 15 and 19 metres depth demonstrated better dispersion and minimal risk of sediment re-entry into navigational channels, making them more suitable for dumping of dredging material. Nearshore sites at 10 and 12 metres depth were found to contribute to sediment accumulation north of the port, providing an added benefit of reducing coastal erosion in that region.

### *Water Levels and Circulation Patterns*

Water level and current studies were carried out for representative months – April (pre-monsoon), July (monsoon), October (post-monsoon), and December (northeast monsoon). Water levels across the identified disposal locations ranged between 0.3 and 3.0 metres, with peaks during flood tides reaching 2.7 to 2.9 metres. Current speeds varied between 0.01 and 1.0 m/s, with the strongest currents observed near river mouths and weaker currents offshore, typically below 0.15 m/s. The predominant current flow was towards the coast or parallel to the shoreline, with only minor alongshore transport occurring at certain nearshore sites. These current magnitudes were not sufficient to cause large-scale sediment displacement, supporting the stability of dredged material deposition at the designated disposal sites.

### *Wave and Current Dynamics*

Wave and current dynamics were assessed to evaluate their implications on navigation safety and sediment management. Within the port basin, wave heights consistently remained below 0.2 metres, ensuring calm conditions for vessel operations. Offshore, wave heights varied seasonally with maximum recorded values of 1.4 metres in April, 2.25 metres in July, 3.4 metres in October, and 1.55 metres in December. Wave periods

ranged between three and 9.6 seconds, depending on the season, with longer periods observed during monsoon and post-monsoon conditions. Wave directions were predominantly from the southwest between April and July, shifted to south-southeast in October, and moved to east or southeast in December. Coupled wave-current simulations indicated that wave-induced currents in the port remained low, generally under 0.2 m/s, maintaining navigational safety and reducing the risk of sediment resuspension.

### *Risk, Safety, and Environmental Management*

The Paradip Port expansion project has been planned with a robust framework of risk management, safety protocols, and environmental protection strategies to mitigate potential hazards arising from both natural and operational factors. The measures outlined in this section aim to safeguard human life, port infrastructure, marine ecosystems, and surrounding coastal areas.

#### Disaster Management Plan (DMP)

A comprehensive Disaster Management Plan has been prepared to address potential threats such as cyclones, storm surges, flooding, and port-related emergencies, including fire and structural failures. Given the port's geographical location along the Bay of Bengal, which is prone to intense cyclonic activity, the DMP places significant emphasis on early warning systems linked to the India Meteorological Department (IMD) forecasts. Evacuation routes, emergency assembly points, and disaster shelters have been designated to ensure the swift and safe movement of personnel during emergencies. The plan includes a communication framework that ensures rapid dissemination of alerts to all stakeholders, including port workers, contractors, ship operators, and local authorities. Structural resilience measures, such as the reinforcement of breakwaters and quay walls, have been proposed to minimize damage from extreme weather events. Regular drills and training sessions are scheduled to keep port staff prepared for various emergency scenarios. Post-disaster recovery measures, including debris clearance, restoration of port services, and coordination with disaster response agencies, form an integral part of this plan to ensure the quick resumption of operations.

#### Oil Spill Contingency Plan

Oil and fuel spills are a significant risk in large-scale port operations, and a dedicated Oil Spill Contingency Plan has been developed to prevent, contain, and mitigate such incidents. Preventive strategies include the enforcement of double-hull tanker usage where applicable, regular inspection and maintenance of pipelines, and strict monitoring during fuel transfer operations. In the event of a spill, immediate containment is prioritized through the deployment of floating booms to prevent the spread of oil. Skimmers, absorbent pads, and response vessels are pre-positioned to handle small to medium-scale incidents effectively. Shoreline clean-up protocols are established in compliance with Central Pollution Control Board (CPCB) guidelines to minimize ecological damage. Furthermore, the plan incorporates continuous surveillance of

marine water quality near the berthing areas to detect any potential leakage or contamination early. Trained response teams are stationed on-site to ensure that containment and recovery operations can be activated within hours of detection.

### Green Ammonia/Hydrogen Risk Assessment

The expansion project includes provisions for green ammonia/hydrogen handling, necessitating a focused risk assessment due to its potential toxicity, flammability, and explosive characteristics under certain conditions. The assessment identified critical hazards such as toxic vapor release during transfer operations, risk of leaks in storage tanks, and occupational exposure risks for workers. Mitigation measures proposed include the installation of advanced leak detection systems with continuous monitoring and automated alarm activation. Storage facilities are designed with pressure and temperature controls, proper ventilation, and secondary containment systems to minimize the risk of accidental releases. Firefighting and neutralization systems specific to ammonia fires (dry chemical extinguishers and water fog systems) are integrated into the facility design. Personnel are to undergo specialized training for handling ammonia and responding to emergency scenarios, including evacuation drills and the use of protective equipment.

### Environmental Safeguards

Environmental protection is a core element of the project's risk management approach. Sediment disposal from dredging operations has been planned to minimize ecological disturbance. Offshore disposal sites at depths of 15 m and 19 m were identified as the most suitable due to their distance from sensitive habitats and their ability to allow natural dispersion of suspended material without intruding into the navigation channel. Nearshore disposal at 10 m and 12 m depths will be selectively used to promote sediment accumulation north of the port, helping mitigate ongoing shoreline erosion. Continuous monitoring of water quality parameters such as turbidity, dissolved oxygen, salinity, and chlorophyll concentrations has been recommended during and after dredging operations to track environmental changes. Seasonal restrictions will be enforced to avoid dredging during critical fish breeding periods. Furthermore, mangrove and coastal vegetation zones will be periodically assessed to detect any stress or degradation linked to port activities, ensuring that compensatory plantation and habitat restoration measures can be implemented promptly if required.

### Project Benefits

The Paradip Port is being expanded to increase its capacity and become a modern, high-capacity maritime hub. Located at the Bay of Bengal and well connected by road and rail, it plays an important role in India's trade network. The project will raise the port's capacity, improving efficiency and reducing logistics costs.

### Key Benefits

The expansion will add new berths, modernize existing berths which will reduce waiting times, lower transport costs, and allow more cargo to be handled, including coal, iron

ore, crude oil, fertilizers, steel, and containers. It will also boost trade in nearby states like Odisha, Jharkhand, Chhattisgarh, Bihar, and West Bengal. Better roads, railway links, and the use of smart technology will speed up cargo movement and reduce turnaround times.

### *Environmental Benefits*

The project includes steps to protect the environment, including, conservation of existing biodiversity, greenbelts development, advanced solid waste management systems, water treatment plants, and rainwater harvesting facilities. These measures will reduce pollution, conserve water, and help maintain a healthy coastal environment.

### *Economic and Social Benefits*

The expansion will create many jobs during both the construction and operation phases. Local people will get priority for employment and will be trained through skill development programs. This will also help small businesses and services in nearby areas grow. Fisheries and related businesses will benefit from the increased demand for local produce such as fish, dairy, and meat.

### *Corporate Social Responsibility (CSR) Initiatives*

The Paradip Port Authority has planned several CSR initiatives to support local communities. These include free health camps, drinking water supply projects, improvements to schools, sanitation facilities, solar street lighting, and skill development programs for youth. A total of ₹194.8 crore has been allocated for these activities, with major investments in drinking water pipelines and treatment plants.

### **Environmental Cost-Benefit Analysis**

The Environmental Cost-Benefit Analysis for the Paradip Port expansion project was conducted in accordance with the EIA Notification, 2006, which requires such an analysis only when recommended during the Scoping Stage as part of the Approved Terms of Reference (TOR). The proposed project area, earmarked for creating additional port facilities, comprises largely barren land. The proposed development is not expected to cause significant damage to sensitive ecosystems, rare species, or key biodiversity components within the project area. Consequently, the expansion will not result in any notable environmental loss in terms of overall productivity or ecological value. Since the existing vegetation is common and widely distributed in the surrounding region, no substantial impact on local biodiversity is anticipated. The costs associated with the project, including the planned investment in the Environmental Management Plan (EMP), are outlined separately in Chapter 10 of the report. Overall, the environmental implications are minimal compared to the substantial socio-economic and trade-related benefits expected from the expansion.

### **Environmental Management Plan**

The Environmental Management Plan (EMP) for the Paradip Port expansion project provides a comprehensive strategy to minimize, mitigate, and manage environmental

impacts during both the construction and operational phases of the port. The expansion aims to increase port capacity and this growth will be supported by sustainable practices. The EMP aligns with national and international environmental regulations and sets forth measures for air and water pollution control, waste management, noise abatement, greenbelt development, biodiversity protection, and continuous monitoring. The EMP estimated the total investment for environmental management measures and the provisions for upgrades over the project's lifetime.

### *Air Quality Management*

The project incorporates robust air quality management measures to control emissions from cargo handling, vehicle movement, and construction activities. During the construction phase, water sprinkling will be conducted 3–4 times daily across high-dust areas, and loose materials will be transported using covered trucks to prevent dust dispersion. Around 200 construction vehicles and equipment units will undergo regular servicing to comply with emission standards (BS-VI or equivalent).

In the operational phase, mechanized cargo handling systems and covered conveyor belts will be deployed, reducing particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) emissions by up to 70% compared to open systems. Dust suppression systems, including mist cannons, will be installed at bulk cargo areas, capable of controlling up to 90% of airborne particles in their vicinity.

### *Water Management*

Water conservation and pollution prevention are key components of the EMP. Effluent Treatment Plants (ETPs) with a cumulative capacity of 5,000–7,000 m<sup>3</sup>/day will treat industrial and domestic wastewater before discharge to meet CPCB standards. Oil-water separators will be installed in high-risk areas such as fuel storage and transfer zones to prevent marine pollution. Rainwater harvesting structures, capable of storing and recharging 30,000 m<sup>3</sup> annually, will reduce dependence on freshwater supplies. Stormwater drainage covering approximately 10 km of the port area will be redesigned to manage heavy rainfall events, particularly during monsoon months, thus preventing contamination of coastal waters.

### *Waste Management*

The waste management strategy for Paradip Port is designed to minimize the impact on the environment by implementing sustainable and efficient waste management practices. The port generates waste from various sources including maritime operations, cargo handling, port activities and administrative tasks. Wastes are classified into hazardous (oils, solvents, batteries, electronic waste, and chemicals from propellant handling), non-hazardous and biodegradable types to ensure proper separation at the source. Special facilities will be established for the collection, storage and disposal of hazardous waste in accordance with the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2016. Non-hazardous materials such as paper, plastics and metals are recycled wherever possible. Organic

and biodegradable wastes are treated through composting or biodigestion to produce compost or biogas for local use. The strategy also includes regular monitoring of waste generation, training programs for port staff and strict enforcement of waste management protocols to comply with national and international environmental regulations, including MARPOL Annex V standards. These efforts aim to transform Paradip Port into an ecologically sustainable and environmentally friendly facility.

### *Noise Control Measures*

Noise pollution will be managed by scheduling major construction activities between 06:00 and 22:00 hours. Acoustic enclosures and silencers will be installed for equipment producing noise above 85 dB(A). Noise barriers with a reduction capacity of 10–15 dB(A) will be constructed around bulk cargo loading zones. Operational noise is projected to remain below 75 dB(A) for industrial areas and 55 dB(A) for residential areas, adhering to CPCB guidelines. Continuous noise monitoring stations will be established at five key locations within and around the port.

### *Greenbelt Development and Biodiversity Protection*

The EMP includes the development of a greenbelt spanning 30–35 hectares, with a plantation density of 1,500–2,000 trees per hectare using native and salt-tolerant species such as *Azadirachta indica*, *Thespesia populnea* and *Pongamia pinnata*. This greenbelt will act as a buffer to reduce air and noise pollution. Nearby mangroves and intertidal zones will be monitored twice annually to detect stress or degradation. In case of vegetation clearance, compensatory afforestation will be carried out at a 1:3 ratio, meaning three new trees will be planted for each tree removed.

### *Environmental Monitoring*

Environmental monitoring will ensure compliance with all prescribed standards. Air quality parameters, including PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, and NO<sub>x</sub> will be monitored quarterly; water quality (BOD, COD, turbidity, and oil & grease) will be assessed monthly; soil quality will be analyzed biannually; and marine ecology will be monitored annually. Data will be reviewed by the State Pollution Control Board (SPCB) and shared with relevant stakeholders.

### *Environmental Setup and Budget*

A dedicated Environmental Management Cell will function supported by qualified environmental specialists, field technicians and monitoring staff. This team will oversee all EMP activities, ensure compliance, and coordinate with contractors, government authorities, and local communities. The EMB budget allocation includes the construction phase, focusing on pollution control infrastructure, monitoring systems, and greenbelt development, and the operational phase, covering maintenance, environmental audits, and community development programs.

## Significant findings of the EIA study

The project integrates strong sustainability measures such as renewable energy adoption (solar and wind), rainwater harvesting, shoreline erosion control, green infrastructure, and circular economy principles in waste management. A dedicated Environmental Management Plan (EMP) outlines strategies for air and water pollution control, spill prevention, occupational safety, disaster risk management, and continuous environmental monitoring. Oil spill contingency planning, green ammonia/hydrogen handling protocols, and climate resilience infrastructure are key components to ensure safe and sustainable operations.

Socio-economically, the expansion will create large direct and indirect jobs, while enhancing regional trade, reducing logistics costs, and generating an additional USD 10 billion in annual trade volume. Corporate Social Responsibility (CSR) programs will focus on drinking water facilities, healthcare, education, and skill development for local communities. The Environmental Cost-Benefit Analysis confirms that the economic and social benefits outweigh the environmental costs, provided that the recommended mitigation strategies are effectively implemented. Through its integrated approach, the project sets a benchmark for sustainable maritime infrastructure, balancing economic growth with ecological preservation and community development.