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CRISIL
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Smart, Safe & Sustainable Ports



FICCI

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Foreword from FICCI



Dhruv Kotak
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I am happy to share with you the FICCI-CRISIL Knowledge Paper on 'Smart, Safe & Sustainable Ports' to be released at the 2nd Edition of Port Infrastructure Conclave with the theme 'Developing Ports for the Future' organized by Federation of Indian Chambers of Commerce and Industry.

There is a worldwide drive to digitalize ports and the global market for 'smart port' segment is projected to be US$ 5.3 billion by 2024 from an estimated US$ 1.7 billion in 2019, at a CAGR of 25 per cent. Industry experts have cautioned that "Smart ports are the only ports that will survive." Therefore, it is no longer a matter of choice but has become the existential requirement for the sector!

India has proactively envisioned this transformation in its Maritime India Vision 2030 document. We are on the path to transform our seaports into "smart ports" and in due course of time, enhancing them to "intelligent ports." Sustained efforts are being put towards introducing Industry 4.0 technologies like AI, IoT, machine learning, automation amongst others to simplify and smoothen the port operations, while enhancing the efficiency and improved safety of workers, vessels, and cargo. Implementing green initiatives, reducing emissions, promoting circular economy practices and adopting a responsible environmental behaviour will remain integral to this transformation process.

The FICCI-CRISIL Knowledge Paper dwells into the key elements that contribute towards creating a smart, safe, and sustainable port. It presents a comprehensive overview of the latest technological advancements, operational best practices, and sustainability initiatives that port operators may like to adopt to optimize port efficiency and reduce environmental impact.

I hope you will find this paper useful. We welcome your suggestions and feedback.

Foreword from CRISIL Ltd



Jagannarayan Padmanabhan
Senior Director and Global Head – Transport, Logistics and Mobility, CRISIL

With a coastline stretching over 7,500 km and 13 major ports, India has always relied heavily on maritime trade. The seaports play a vital role in the country's economy, serving as gateways for international trade and hubs for the movement of goods and commodities.

Major Indian ports handled 720.29 million tonnes (MT) of cargo traffic in FY22, which indicated a compound annual growth rate (CAGR) of 2.89% from FY16 levels. Until December 2022, the capacity of India's major, as well as non-major, ports was 2604.99 million tonnes per annum (MTPA). All of India's major ports handled 70.12 MT of cargo traffic in January 2023, logging a 12.2% increase compared with the corresponding period a year ago. Further they handled 720.29 MT of cargo in FY22. India's goods exports were worth US$ 417.8 billion in FY22, having increased 40% compared with the previous year.

In accordance with the automatic route, the Indian government has permitted up to 100% of foreign direct investment (FDI) for projects involving the development and upkeep of ports and harbours. Between April 2000 and March 2022, FDI into Indian ports totalled US$1.63 billion. Enterprises into the building, management, and maintenance of ports, inland waterways, and inland ports are granted a 10-year tax exemption. The government has also launched the National Maritime Development Programme (NMDP) — aimed at promoting the maritime industry, with a budgeted investment of US$ 11.8 billion. The Ministry of Shipping received a total budget of Rs. 2,218 crore (US$ 270.20 million) in Union Budget 2023-24. (*Source – Ministry of Finance, Government of India*)

By 2035, India intends to invest US$ 82 billion in port construction. The Major Port Authorities Bill, 2020, was adopted by the Indian government to strengthen major port governance and decentralize decision-making.

In contrast to the ports' current capacity of 2,406 MMTPA (million metric tonnes per annum), as per assessments done under the Sagarmala Plan, cargo volumes at ports are predicted to reach 2,500 MMTPA by 2025. Further, to accommodate expanding traffic, a roadmap has been created to boost Indian ports' capacity to 3,300+ MMTPA. This includes new port development, capacity expansion of existing ports, and improvements to the ports' operational efficiency. Overall, 206 port modernisation projects totalling Rs. 78,611 crore ($10.71 billion) are underway. Of these, 59 projects totalling Rs. 24,288 crore (US$ 3.31 billion) are being executed, and 81 projects worth Rs. 24,113 crore (US$ 3.29 billion) have already been completed.

With India’s economy growing rapidly, demand for efficient and sustainable port infrastructure has become more pressing than ever before, giving rise to the need for a safe, smart, and sustainable port system that can meet future demand, while protecting the environment and ensuring the safety of its workers and stakeholders.

The proposed green port policy is a major push towards propelling India towards becoming a global leader in safe, sustainable, and eco-friendly ports. Various measures have been identified, including ramping up the use of renewable energy, curbing air emissions, enhancing water usage efficiency, implementing better solid waste management practices etc. Amongst other targets, the major ones include lowering carbon emission per tonne of cargo handled by 30% by 2030, and 70% by 2047, setting up LNG, green ammonia bunkering and increasing green belt in ports by 20% by 2030.

In this white paper report, we explore the challenges that India's ports are seeing and the need for a comprehensive approach to address these issues. We examine critical factors that contribute to a safe, smart, and sustainable port system, including digitalisation, innovation, and environmental sustainability.

The report also highlights the importance of collaborations and partnerships in achieving these goals, as the challenges are complex and require a multifaceted approach.

We believe this report will provide valuable insights for policymakers, port authorities, and stakeholders invested and contribute to the ongoing efforts for creating a safe, smart, and sustainable port system for India's future — one that will meet demand arising from a rapidly evolving global economy, while protecting the interests of its citizens and the environment

Need for Safe, Sustainable & Smart Ports

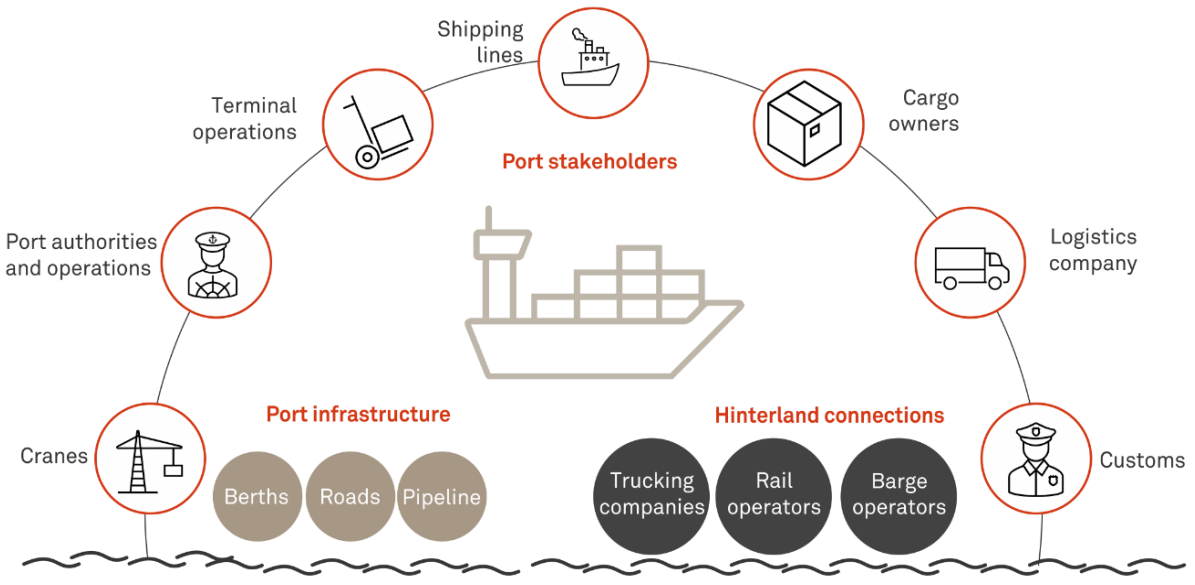
Ports and harbours are facing stiff competition in terms of gaining market share and delivering a more effective and secure flow of goods worldwide. High-performing ports are implementing smart technologies to manage operations better, facing new challenges in maintaining safe, secure, and energy-efficient facilities that mitigate environmental impacts. The concept of a smart port has emerged in this context.

India needs sustainable ports to support its growing economy and address environmental concerns. Rapid growth of port infrastructure and operations has also had significant environmental impacts, such as pollution and habitat destruction. By adopting sustainable practices, such as reducing emissions, conserving energy and water, and managing waste, Indian ports can mitigate their environmental impact and contribute to the country's overall sustainable development goals. Sustainable ports can also improve the social and economic well-being of surrounding communities by creating job opportunities, supporting local businesses, and enhancing the quality of life for residents.

To achieve these objectives, providing a secure environment for the safe and efficient handling of ships and cargo, ensuring the safety of life at sea, protecting the marine environment, and ensuring the security of port facilities is critical. This includes implementing measures to prevent accidents and incidents, as well as to respond effectively to emergencies such as oil spills or natural disasters.

India needs safe ports because it has a long coastline of over 7500 km and handles a large volume of maritime traffic, making safety a critical concern. Accidents, such as ship collisions, groundings, and oil spills, can have severe consequences for the environment, economy, and human life. Additionally, the threat of maritime terrorism and piracy is a global concern, to which, India is no exception. Safe ports are essential for mitigating these security risks, ensuring the safety of ships and crew, and protecting port facilities.

Figure 1 Smart port value chain ecosystem



Source: CRISIL analysis

By prioritising safety in port operations, India can enhance its reputation as a reliable and responsible trading partner and promote sustainable economic growth.

The smart port ecosystem is revolutionising the way ports operate, making them more efficient, sustainable, and safe. These technologies integrate the entire port system, connecting stakeholders, hinterland connections, and port infrastructure in a seamless and smart manner.

Integrating the port ecosystem with technologies will require the deployment of cutting-edge IoT, AI, blockchain, and big data analytics solutions. These technologies enable port stakeholders to collect, share, and analyse data in real time, enabling them to make informed decisions and optimise port operations.

With real-time data on vessel movements, cargo flows, and port infrastructure, port operators can optimise their resources, reducing waiting times and increasing throughput. This, in turn, reduces costs and enhances the ports' competitiveness.

Moreover, smart port technologies can help reduce the environmental impact of port operations. By monitoring energy consumption and emissions, and through waste management, port operators can implement more sustainable practices and reduce their carbon footprint.

India's ranking in the World Bank's Logistics Performance Index 2023 has improved by six places, and this is attributed to investments made in technology, soft and hard infrastructure. The Indian government has given priority to developing trade-related infrastructure that connects port gateways to economic centres located in the hinterland. This initiative has enhanced port performance, resulting in an average dwell time of three days for containers, comparable to Singapore's and better than that of some developed countries, between May and October 2022. Additionally, the digitalization of end-to-end supply chains has contributed to reduction in port delays in emerging economies such as India. The shipping industry is experiencing a rise in demand for environmentally friendly options, with 75% of shippers looking for such solutions when exporting to high income countries, and this is a positive development for sustainable port infrastructure.

Smart and Sustainable Ports

The maritime industry, which transports 90% of all international cargo volumes, has undergone technological innovation, advancement, and transformation. These changes are aimed at increasing operational efficiency, reducing costs, and easing the process of doing business.

Digital transformation has been one of the major forces supporting change in the port and maritime industries over the last 10-15 years. Ports will need to undergo digitalization and the integration of end-to-end processes and stakeholders in the entire supply logistics value chain of the maritime sector if data-driven decision-making and investment strategies are to be implemented.

State-of-the-art technology systems such as automated cargo handling with the help of robotics and drones, IoT, blockchain, AI and machine learning, and big data analytics are expected to help considerably in making ports safer and more sustainable.

Initiative undertaken	Impact
• PCS 1x • E-marketplace transport solution • Integration of IGM, Out of Charge & SMTP EDI Msg. • RFID/OCR-based gate automation • Container tracking by LBD portal • Mobile X-ray container scanners	• Gate processing time reduction for each TT from 5-10 minutes to 1-2 minutes • Container dwell time reduced from 9.13 days to 3.68 days • Average import dwell time reduced 60% • Average export dwell time reduced 7% • Gross berth productivity has **increased by 11%** • Gross Crane productivity has **increased by 18%**

Source: CRISIL analysis

There are 12 main ports in India, and each one has adopted technologies that meet its needs. Current information technology (IT) systems in use are:

1. Port operations management system
2. Port community system (PCS)
3. Standard ERP (Enterprise resource planning) System
4. Auxiliary IT system

Common Challenges

Although Indian ports have implemented technologies and initiatives, the following challenges remain:

1. Customs department message exchange delays interfere with effective port operations and PPP operators are hesitating to undertake PCS 1x, which negates the advantages of an integrated system.
2. The DGS IT system presently in use is outdated and needs to be upgraded to meet the industry's current needs.
3. Concerning the seafarer profile, examination, certification, ship registration, etc., there are problems, mostly with the duplication of data input, non-standardisation of formats, payments and refunds, and the central database, among others.
4. Similar issues exist with IWAI's IT systems. These include ineffective information exchange caused by an unreliable network, challenges in integrating terminal operations, and difficulties in tracking the amount of dredging by each dredger.

Other Issues

1. High manual involvement
2. Increased paperwork and duplication
3. Lack of international stakeholder integration
4. Lack of SOPs and timetables
5. Inconsistent monitoring and traceability of cargo
6. Lack of modern technological interventions
7. Insufficient data exchange between agencies to provide a comprehensive view
8. EXIM processes that are not digitalised

Way Forward

1. E-gate 2.0 at all ports based on computer vision and OCR technologies

The E-gate 2.0 at ports will be based on computer vision, fully automated terminal operations, and services with holistic integrated systems to enable terminal operators to increase productivity gains and handle more cargo with lesser manual involvement.

2. Implementation of sensor-based marine devices

New dredging works are required for increasing ships' efficiency levels and expanding coastal infrastructure, which more recently, includes provisions for renewable energy developments. New port developments and the expansion of current facilities — including larger and deeper access channels, turning basins, and appropriate water depths — are required along waterside facilities to accommodate vessels. Accurate data from sensors ensures that dredging operations comply with set regulations. For accurate data, all sensors should be fully calibrated before the project begins. This would allow for more informed critical decision-making on water allocation, flood mitigation, and environmental flow requirements, which have implications on water security, the industry, and the economy.

3. Drone-based inventory management

Inventory management using unmanned drones in ports is a fully automated process. With the help of the new technologies, warehouse inventory management at ports will become automated, and will not interfere with daily operations or require assistance from people.

4. Automation of MHCs, pilotage, mooring and anchorage

Automated mooring would increase the operational window for product transfer through a wider range of berthing and environmental conditions than mobile harbour cranes (MHCs) and mandatory pilotage for unloading, improving safety, lowering resource and space requirements, requiring less time to moor vessels, and consequently minimising infrastructure investment to increase berthing capacity.

5. Unmanned automated terminal operations

Unmanned terminal operations will improve container tracking and eliminate losses arising from misunderstandings and human errors when handling containers.

Steps for Improvement

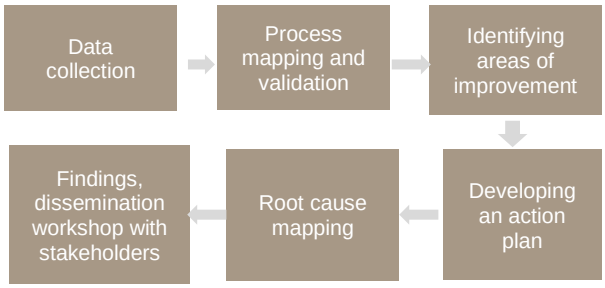
1. Upgradation of terminal operating system (TOS)

- Transform the terminal operating system for operations, planning and forecasting system that aids ports in resource optimisation
- Crane deployment on berths, dynamic task distribution, and advanced crane scheduling to help ports operate more cost-effectively

2. Port process improvement toolkit implementation:

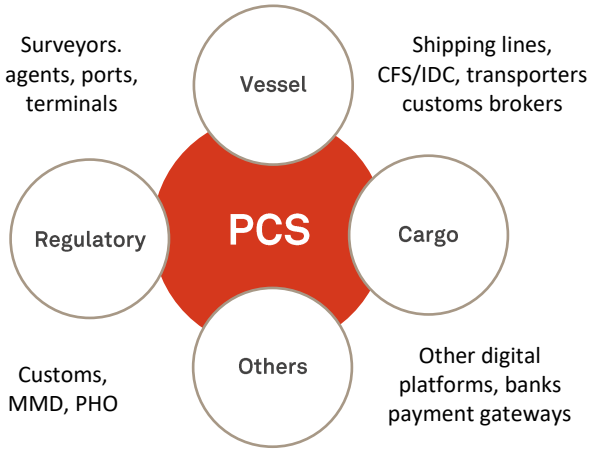
A comprehensive toolkit can be implemented for the port processes as below:

Figure 2 Six-step process toolkit implementation



Source: CRISIL analysis

3. Integrating existing systems (PCS/ NLP/ TOS) with Unified Logistics Interface Platform



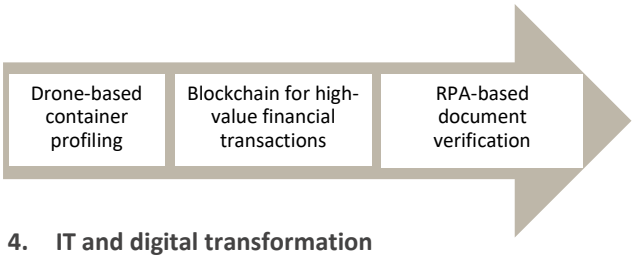
Unified Logistics Interface Platform
Ministry of Civil Aviation
Ministry of Finance
Ministry of Ports, Shipping and Waterways
Ministry of Road transport & Highways
Ministry of Commerce & Industry

Source CRISIL analysis

Implementing smart document management systems

For logistics processes like document verification usage of robotic process automation (RPA) can be promoted.

Blockchain technology for essential records and documentation, as well as high-value financial transactions



4. IT and digital transformation

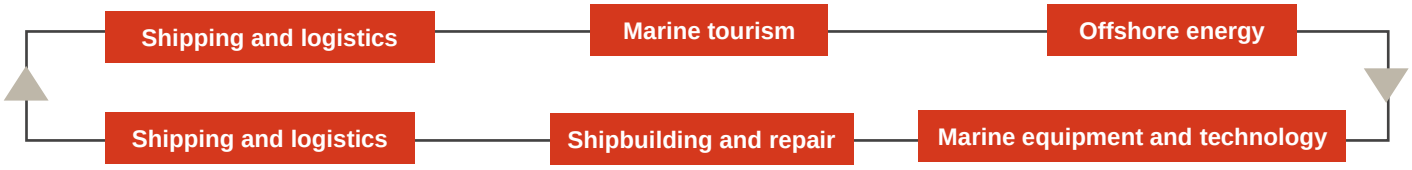
Development of smart and intelligent sensing through integrated IoT-based marine environment monitoring with advanced ocean analytics (AI & ML), with complete mapping, monitoring, and modelling of the waters, and coordinated networked operations would support the ports to improve their operational efficiencies.

IoT in the ports sector	AR in the ports sector
Smart interconnected devices such as sensors, and wearable devices providing real-time information flow to eliminate bottlenecks	Augmented reality (AR) devices to help stimulate conditions that can impact port operations

Source: CRISIL analysis

5. Smart maritime clusters and city

Promoting smart maritime industrial clusters to encourage port-led industrialisation



Source: CRISIL analysis

The goal of a smart maritime industrial cluster is to create a collaborative environment that encourages innovation, reduces costs, and creates economies of scale, which can help to drive sustainable economic growth and job creation in the maritime industry.

Sustainable ports

Port authorities and operators are facing challenges in the sustainable development of ports, particularly with regard to the role and impact of ports. The maritime sector's adoption and implementation of internationally recognised health, safety, and environmental (HSE) standards has highlighted the importance of incorporating safety, health, and environmental objectives and procedures into every aspect of the management system, not just operational activities.

Ports worldwide are striving to become carbon neutral in future. Port of Rotterdam aims to achieve this by 2050, implementing measures such as using surplus energy through steam exchange, capturing and reusing CO_2, replacing coal with gas and offshore wind power, and developing recycling, biomass, and hydrogen hubs. Port of Hamburg aims to become carbon neutral by 2040, with all major terminals being equipped with onshore power by 2030, compensating for CO_2 emissions, through emissions reduction certificates. Port of Helsinki plans to become carbon neutral by 2035 by implementing initiatives pertaining to shore power capabilities, low-emission vehicles, electrification of work machine infrastructure, biofuels, LED lighting, and solar panels. Singapore's Maritime Port Authority has developed a decarbonisation roadmap to transition to low-/zero-carbon energy sources by 2050, with a dedicated research and development (R&D) hub for decarbonisation technology.

Environmental Protection

Operation phase

Emissions from the engines of ships, tugs, and boats that run in the port, as well as diesel generators, welding and cutting during maintenance activities, and vehicles used for various port operations, are responsible for air pollution. Noise pollution is caused due to the use of mechanised heavy equipment. Chemical spillage is caused due to poorly maintained equipment, and pipes also contribute to soil pollution. Apart from this, waste generation from ports will also add to the pollution. Spillage and discharge of unclean water into seawater or onto coasts can lead to severe water pollution. This can cause major damage to the marine ecosystem and enter the food chain through marine life.

Construction phase

Constructing a port/terminal/berth on land can harm animal habitat due to the felling of trees and clearing of vegetation, and construction work can lead to dust suspension and increased vehicular movement, degrading air quality. Construction waste can also pollute land or coastal waters if not disposed of correctly. On the waterfront, dredging can produce silt, which poses a threat to marine ecology if not properly disposed of and building port infrastructure can harm the marine environment and ecosystem.

Other sources of marine pollution include:

- Sewage from port operations
- Bilge and ballast water from vessels

Best Practices to Improve Air Quality & Pollution at Ports

Green belt

Developing green belts in and around ports can have numerous benefits for the environment, including capturing emissions and reducing noise pollution. This can also help preserve biodiversity and regulate the climate of surrounding areas. The roots of trees planted within green belts can help stabilise the soil and prevent erosion due to wind or water and can contribute to maintaining the water table and preserving soil moisture.

Green belts can also play a significant role in reducing pollution levels in port areas. In particular, the creation of green belts near material handling areas can be effective in mitigating the effects of dust and noise on the environment. By creating a natural barrier between the source of pollution and surrounding areas, green belts can help reduce the spread of pollutants and improve air quality in port areas.

It is crucial to prioritise the establishment of green belts and implementation of other similar measures to mitigate the impact of port activities on the environment.

The Ministry of Environment, Forest and Climate Change (MoEF&CC) has made it mandatory for ports to develop green belts as part of their Environment Management Plan

(EMP) to effectively control air and noise pollution. The MoEF&CC has provided guidance manuals to aid in the implementation of this initiative.

According to the current recommendations from the MoEF&CC, ports should aim to make 33% of their total area green. However, the percentage of the green belt area in Indian ports currently varies from 3% to 36%. This implies that there is significant room for improvement in this area, and more efforts are needed to bring all ports in line with the recommended standard.

Ports without a large expanse of land parcels available for expansion are facing trouble in creating a 33% green belt area. Such ports are advised to discuss with the MoEF&CC to permit for mangrove plantations as alternative land. This can be developed for 33% greenbelt cover.

Development of environmental regulations for all vessels

After the development of green fuel infrastructure on land, it is essential to establish policies and guidelines for fuel obligation that apply to both domestic and international vessels operating in Indian waters. Such policies and guidelines can promote the use of cleaner and more sustainable fuels, reducing the ecological impact of vessel operations. These can help set targets for reducing greenhouse gas emissions from vessels and require regular reporting and verification processes pertaining to emissions data.

The development of these policies and guidelines should require the involvement of stakeholders from the shipping industry, government agencies, and environmental organisations to ensure that the policies/guidelines are practical and effective, and consider challenges unique to the Indian maritime sector, such as the high volume of coastal shipping and limited availability of infrastructure in some areas.

Waste Management

Sewage and water treatment plant

The government (Department of Industrial Policy and Promotion (DIPP)) should aim to support industrial clusters located near ports and waterways by providing them with sewage and effluent treatment plants. This will ensure that the industries in these clusters are able to function without harming the environment, by treating and disposing of their wastewater in a responsible manner.

To realise this, the government needs to allocate funds from the central and state budgets to provide necessary infrastructure for the installation and operation of these treatment plants. By doing so, it would encourage sustainable and responsible industrial practices that are in line with environmental regulations.

Support from the government may include conducting training programmes and workshops and providing other resources to help industries understand the importance of proper wastewater management and the steps they can take to minimise their environmental impact. The government can also provide technical assistance to industries to help them implement best practices for wastewater management.

Recycle

The United Nations' Sustainable Development Goals (SDGs) are a set of 17 interconnected goals that aim to address global challenges such as poverty, inequality, climate change, and environmental degradation. These goals were adopted by all UN member states in 2015 as part of the 2030 Agenda for Sustainable Development, which seeks to create a more equitable, peaceful, and sustainable world for all.

SDG 6: Clean water and sanitation, SDG 11: Sustainable cities and communities and SDG 12: Sustainable consumption and production patterns promote recycling to a large extent. India has taken a significant step towards promoting responsible and sustainable ship recycling practices by ratifying the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, which is aimed at ensuring that ships are recycled in a safe and environment-friendly manner, reducing risks to human health and the environment.

Recommendation

To promote the effective implementation of these conventions, it is recommended that the development of KPIs be used to measure progress and identify areas for improvement.

London Convention and Protocol Convention (LC/LP) can be ratified and effectively implemented to promote sustainable and responsible practices in the industry.

Recycling through circular economy

Circular economy is a concept that can be applied to marine ports to promote sustainable development and reduce waste.

The circular economy approach involves the efficient use, reuse, and recycling of resources, which can help reduce negative environmental impact

Circular practices, such as recycling and renewable energy use, can be adopted in the port environment to achieve these goals. Additionally, sustainable practices such as waste management, green infrastructure, and eco-friendly transportation can be followed to reduce negative environmental impact further.

By embracing circular economy principles in marine ports, achieving greater sustainability, while also creating economic opportunities and reducing costs, is possible.

Fundamental guidelines for establishing a circular port include the following:

Figure 3 Guidelines for establishing circular port

Geography - prominent hub for industries such as steel, chemicals, and refining
Access to large **hinterland** and hinterland connections
Major hub for **international cargo flow** and high-traffic region

Source: CRISIL analysis

Rotterdam port follows the below framework to transition to a circular port, which can also be used by the Indian maritime sector.

1. Innovation ecosystem

Encouraging the establishment of start-ups, promoting their growth and development into established businesses, and fostering connections to existing clusters, with emphasis on promoting innovation by port authorities.

2. Sorting and recycling

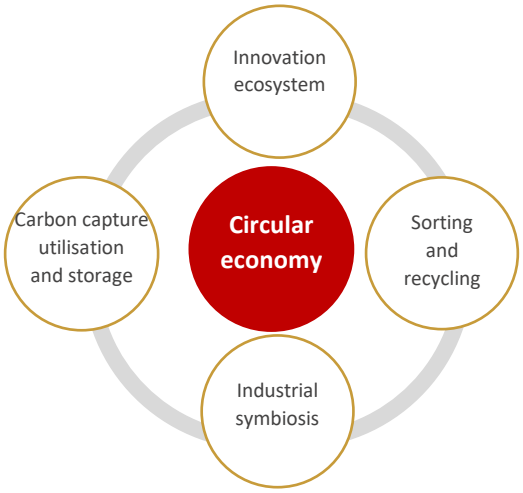
The objective is to create and deploy practical technologies that can transform waste into new products, which will help streamline waste into industries that can use it as raw material.

3. Industrial symbiosis

Creating infrastructure and fostering partnerships for exchanging products and residual streams, such as waste, heat, steam, and solid waste; port authorities will need to identify and assist industries capable of closing circular loops.

One example would be using the sand from dredging for construction sector industries to complete the circular link.

Figure 4 Circular economy



Source: CRISIL analysis

4. Carbon capture utilisation and storage (CCUS)

Port authorities must prioritise the reutilisation of CO_2 in greenhouses and sub-surface storage to minimise its release into the environment.

In future, CO_2 may also serve as a raw material for creating value-added products, such as chemical building blocks, synthetic fuels, or mineral building materials.

The goal of the centre is to create a regulatory framework and roadmap for the adoption of alternative technologies in green shipping, promoting carbon neutrality, and circular economy in India's shipping sector. India plans to increase the percentage of renewable energy to 60% of each major port's total power demand, which is currently

less than 10%, by implementing solar and wind-generated power.

Green Energy

The ports and maritime sector will play a significant role in reducing global carbon emissions and mitigating the effects of climate change. The sector accounts for a considerable share of global carbon emissions and, therefore, must take proactive steps towards decarbonisation.

The following are a few strategies to achieve carbon neutrality:

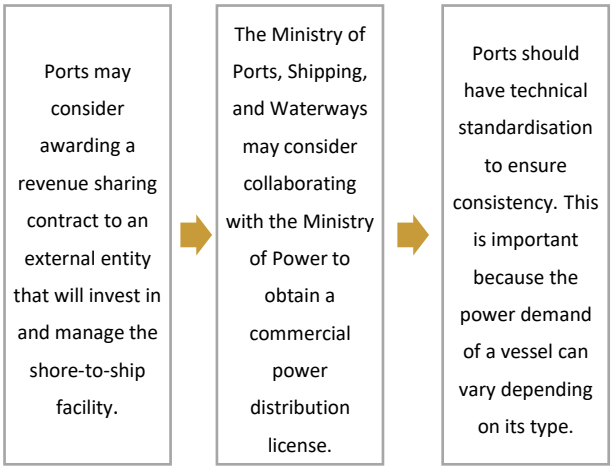
- Implementing steam exchange and heat networks to supply and reuse surplus energy
- Capturing and storing carbon dioxide in greenhouses for reuse
- Replacing coal with gas and offshore wind power to generate electricity
- Exploring other renewable energy sources, such as solar and hydro power
- Promoting efficiency measures to reduce overall energy consumption
- Developing and adopting zero-emission technologies in the transportation and shipping sector

Shore-to-ship power supply

An effective approach to decrease emissions while ships are at berth is to supply them with electricity from the national grid rather than generating electricity using their own auxiliary diesel generators.

This necessitates the installation of a shore-side electricity supply arrangement to enable ships to access electricity while docked.

The following factors should be considered while implementing shore-to-ship supply:



Green Efficiency

Implementing various incentives for discounts in port dues can highlight the importance of sustainable practices to the shipping industry.

These are some indices and standards for green efficiency of ships:

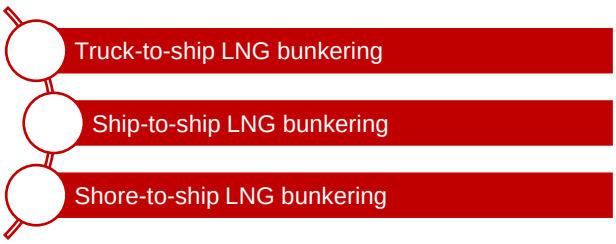
- RightShip GHG Emissions Rating
- Environment Shipping Index
- Green Award
- Clean Shipping Index
- Green Marine
- Energy Efficiency Design Index

To encourage the use of clean marine fuel and promote sustainability at ports, the Indian port authority should consider recognising any of these rating/certification programs. This would boost domestic adoption of clean marine fuel and promote sustainable practices at ports.

Liquefied natural gas (LNG) bunkering

Ships belonging to diverse categories, such as container and cruise ships, are equipped with engines that are capable of utilising LNG fuel to reduce the emission of harmful pollutants from the ship's exhaust system.

Different types of LNG bunkering include:



Leading ports, such as Rotterdam, Hammerfest, Barcelona, Cochin, Singapore, Yokohama, Montreal, Fourchon, Panama, and Jacksonville, already have LNG bunkering programs.

Accelerated adoption of renewable energy

The Ministry of Ports, Shipping, and Waterways has announced that India aims to raise the proportion of renewable energy used to meet the total power requirements of its major ports to 60%.

Interventions suggested

Solar power: Ports can devise long-term plans such as promoting the adoption of renewable energy sources by utilising solar photovoltaic. To accelerate the transition to renewable energy, other ports could use this technology for rooftop installation and mooring and dolphin operations.

Wind energy: Several major ports, such as Deendayal Port Trust (DPT), V.O. Chidambarnar Port Trust, and Kamarajar Port, have already installed significant renewable energy infrastructure. In addition, DPT has taken steps to implement a 20-megawatt wind energy plant.

An intervention involving two key steps can help promote the adoption of renewable energy. The first step would be identifying suitable areas within the port land, shallow waters, and breakwaters to develop onshore wind farms, and the second step would be exploring the possibility of setting up windmill farms through a public-private partnership (PPP) structure. This would enable ports to tap into wind as a sustainable energy source and help reduce their dependence on non-renewable sources of power.

Hydrogen- and ammonia-based fuel cells to power port-side equipment/vehicles

The Ministry of Ports, Shipping, and Waterways can collaborate closely with national laboratories, universities, and industry partners to overcome key technical challenges in fuel cell development and provide support to accelerate the adoption of hydrogen- and ammonia-based fuel cells.

The only emissions from hydrogen-powered equipment would be electricity, water, and heat.

Biofuels

Presently, government guidelines allow for blending of biodiesel/bioethanol with diesel/petrol, with the percentage of ethanol blending in petrol at around 2.0% and that of biodiesel blending in diesel at less than 0.1%. This can be done without making significant modifications to existing engines.

Port authorities can consider a PPP model for the retrofitting of trucks and development and operations of biodiesel retail outlets at ports. A pilot PPP model can be explored initially, and based on the results, it can be extended to other ports. The PPP structure can be similar to that used for LNG-based vehicles.

As technology and hardware become more accessible, the use of biodiesel in its purest form should be promoted in the long run.

Battery-powered equipment

Battery or electric drive trains are being increasingly preferred by global ports on account of their better economics compared with diesel engines. As a result, these ports are opting for the electrification of all equipment to reduce their environmental impact while also lowering operational cost.

To achieve complete electrification within the next 10 years, ports shall make it mandatory to purchase electrical equipment as a replacement for the existing equipment, such as RTGCs (Rubber tyred gantry crane), reach stackers, carriers, and forklifts.

Carbon-Neutral Ports

Vessels, work machines, heavy traffic, and the port's own operations are the major sources of carbon dioxide emissions. These emission sources have led to key areas being identified and a timeline being established to implement the strategies to achieve carbon neutrality at ports.

Figure 5 Strategic areas for carbon neutrality at ports

Strategic areas for carbon neutrality at ports
Clean fuel – land based
Clean fuel – water based
Digitised port operations
Renewable/ clean energy
Recycling/ greening

Source: Maritime Vision 2047

In line with the target of carbon neutrality at ports, India intends to initiate over 20 pilot projects in its green maritime shipping plan. The projects include one hydrogen fuel ferry, five electric water taxies, two hybrid electric Ro-Ro ferries, two hybrid LNG electric cargo carriers, one hybrid tug at Jawaharlal Nehru Port Trust, three dual-fuel container Ro-Ro ferries, green hydrogen/ammonia tugs each at four major ports, one green hydrogen/ammonia-propelled coastal cargo bulk carrier, and one green hydrogen/ammonia-propelled offshore vessel. Pilot runs of LNG, electric, and hybrid Ro-Ro ferries have already been conducted on multiple national waterways by using homegrown green technology. Retrofitting existing vessels to low carbon emission vessels could be a major breakthrough in achieving carbon-neutral ports.

Safe Ports

India relies heavily on its ports for trade and commerce, making it one of the most strategic maritime countries worldwide. Ports are critical to the country's economy, and any disruption in their operations could result in severe consequences. Therefore, the Indian government has implemented various measures to ensure the safety and security of these ports, including implementing access control and cybersecurity protocols to prevent unauthorised access and screening cargo and containers for potential security threats. Given the importance of ports to domestic trade, any disruption in their operations could lead to significant economic losses.

Why do we need port safety?

Safety is a critical factor for the effective operations of ports. Ports need to be secure to ensure the safety of workers and their surroundings. Being situated in coastal areas, ports are vulnerable to natural disasters, such as cyclones, tsunamis, and floods. If ports do not have efficient safety and recovery procedures in place, such disasters can severely impact operations. It is essential to have a safety and rescue plan for cargo and vessels at ports, as accidents can compromise security. Moreover, to enhance port operations, it is crucial to address concerns such as vessel collisions, equipment accidents, and hazardous material safety.

This is especially important in light of several instances of concerns regarding the vulnerability of the Indian ports.

Butcher Island: Mumbai Port Fire (2017): In 2017, a major fire broke out at a fuel tank farm of the Mumbai Port, damaging several high-speed diesel tanks and causing significant financial losses. The fire was reportedly caused by a thunder shower.[1]

Visakhapatnam gas leak (2020): In May 2020, a gas leak occurred at the LG Polymers chemical plant near Visakhapatnam Port, resulting at least 11 people dying and injuring several others. The incident raised concerns regarding the safety of chemical storage facilities near ports.[2]

Oil spill near Ennore Port (2017): In January 2017, two ships collided near Ennore Port in Tamil Nadu, resulting in an oil spill that affected the coastline and the local fishing community. The incident raised questions about the adequacy of response mechanisms in place to deal with such emergencies.[3]

Haldia Port cyberattack (2017): In June 2017, the Haldia Port in West Bengal was hit by a cyberattack that disrupted operations and caused significant financial losses. The attack was reportedly carried out by a group of hackers who demanded a ransom to restore the port's systems.[4]

In another instance, a major port of India was hit by a cyberattack in February 2022, disrupting its operations.[5]

These incidents demonstrate the importance of prioritising safety in port operations and the need for effective risk management and emergency response measures to prevent accidents and incidents.

Current initiatives

The main safety and risk-prevention measures implemented in ports are:

1. Detailed staff training
2. Proper detection of ground faults
3. Opening of circuit breakers on the ship as well as the shore when faults occur
4. Efficient disconnection during emergencies due to weather or excessive vessel movement relative to the pier
5. Effective communication between the ship and the shore
6. Standard operating safety procedures shared by the ship crew and shore-side operators & Indication lights that indicate the connection is safe to touch

[1] https://economictimes.indiatimes.com/news/politics-and-nation/fire-fighting-operation-on-butcher-island-over-mumbai-port/articleshow/61001283.cms?from=mdr

[2] https://timesofindia.indiatimes.com/city/visakhapatnam/vizag-over-1000-fall-sick-after-gas-leak-from-chemical-plant/articleshow/75590112.cms

[3] https://www.thehindu.com/news/cities/chennai/ennore-oil-spill-what-is-happening/article20044550.ece#:~:text=Two%20ships%2C%20the%20Dawn%20Kanchipuram,primary%20cause%20of%20the%20accident

[4] https://www.hindustantimes.com/india-news/cyber-attack-malware-hits-jawaharlal-nehru-port-operations-in-mumbai/story-xGtbHwvZI4bX5RgJCUBN3L.html

[5] https://www.itln.in/shipping/cyber-attack-cripples-jnpt-container-terminal-1344448

Way Forward

- There should be increased cybersecurity, including development of digital technologies to reduce cyber threats and early detection of, and swift response towards, cyberattacks.
- The crew, ship, cargo, and even ports may not be safe when it comes to cybersecurity issues, which can break down continuity of operations and disturb various digital processes, making them vulnerable to unauthorised access, manipulation, and disruption.
- Standardised procedures will help manage information and cybersecurity. Furthermore, developing standard operating procedures and conducting annual drills will help assess the maritime industry's emergency response to cyber and information security threats.
- There should be increased port security measures, such as container scanning throughout ports, drone-based aerial surveillance, geographic information system/ global positioning system (GIS/GPS)-based asset/vehicle tracking, and next-generation patrol vessels, among others.
- Advanced navigation research simulators and smart buoys can aid search and rescue efforts, and automated warnings and analysis can help proactively manage incidents of navigation and operational safety.
- Marine equipment and systems, such as underwater hull cleaning and inspection, and autonomous examination of buildings can reduce the risk of operating at heights.
- Institutional initiatives, such as developing new regulations, standards, and guidelines; deploying advanced technologies; and promoting best practices will play a vital role in ensuring the safety and security of Indian ports. These initiatives will help address emerging risks, such as those related to cybersecurity, climate change, and the use of new technologies such as autonomous vessels.
- Institutional initiatives will also be critical in building a culture of safety and security among port stakeholders, including port operators, shipping companies, and port workers. This can be achieved through training and capacity building programs, awareness campaigns, and establishing safety and security management systems.

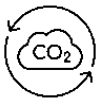
1. Policies and regulations:

Investing in technology and infrastructure	Investing in advanced technologies, such as deployment of high-tech surveillance systems, container scanners, and cybersecurity measures, enhances the safety and security of ports.
Strengthening the legal framework	Building a comprehensive legal framework that outlines the responsibilities and obligations of all stakeholders involved in port safety and security. Creating a dedicated port safety and security act to provide guidelines for best practices.
Enhancing coordination between agencies	Improving coordination and information sharing between agencies to ensure a seamless response in case of any security threats.

Worker safety and disaster management committee plan

Forming a safety committee	Developing safety protocols and guidelines	Conducting regular safety audits	Robust disaster management plans	Regular drills and exercises

Case Study 1 - Port of Rotterdam



- The Port of Rotterdam, one of the largest ports in the world, has set an ambitious goal to become carbon neutral by 2050. To achieve this, the port is taking a comprehensive approach, targeting various areas of improvement.



- One of the strategies the Port of Rotterdam is pursuing is the supply and reuse of surplus energy through steam exchange and heat networks. By capturing and utilising excess heat and energy from various industrial processes, the port can reduce its reliance on fossil fuel and lower its overall carbon footprint.



- Another approach the port is taking is the storage and use of captured carbon dioxide (CO_2) in greenhouses. By capturing CO_2 emissions from industrial processes and directing them to greenhouses, the port can reduce its emissions while also promoting sustainable food production. The port is also using solar power in rooftops to ensure cleaner electricity production.



- The port is pursuing a switch from coal to gas and offshore wind power to generate electricity. Coal is a major source of greenhouse gas emissions, so switching to cleaner alternatives, such as gas and wind power, can significantly reduce the port's carbon footprint. In addition, it is developing hubs for international recycling, biomass, and hydrogen, which will support sustainable, circular economies and further reduce emissions.



- The port is developing collective waste treatment installations to manage wastewater and organic waste flow. This initiative is expected to provide technical benefits, cost savings, and environmental advantages to the participating companies. The port has started implementing innovative fiscal incentives, such as offering discounts on port dues for inland vessels that possess a Green Award certificate.



- The Port of Rotterdam has also adapted global integrated digital solutions to promote Multiple industry collaboration providing and integrated solution across stakeholders. This includes usage of technologies like Internet of Things, Enterprise Management Services. Smart Quay walls in Rotterdam save up to 1 hour in berthing time which translates savings of up to US$80,000.



- Simulators have been adopted by the Port of Rotterdam to enable larger vessels to navigate through different scenarios, while also generating models to improve dredging efficiency in shallow waters, varying tidal conditions and currents.

Case Study 2 - Port of Singapore

The Port of Singapore is one of the busiest and most important ports globally. Located on the southern coast of the island of Singapore, it handles a significant amount of international maritime trade. The port, operated by the Maritime and Port Authority of Singapore (MPA), is known for its efficiency, reliability, and advanced technology. It is a major hub for shipping, serving as a gateway to Asia and connecting to more than 600 ports in over 120 countries.

The port's several terminals cater to different types of cargo, including containers, bulk cargo, and oil and gas. It also offers a wide range of services, such as ship repair, bunkering, and logistics support. In addition to its importance to international trade, the Port of Singapore is known for its commitment to environmental sustainability. The MPA has implemented a number of initiatives to reduce the port's carbon footprint and promote sustainable practices.

Overall, the Port of Singapore is a vital part of global economy and plays a crucial role in facilitating trade and commerce between Asia and the rest of the world.

Singapore implements training programs through Maritime Ports Association

- Trainings and support are provided to maritime professionals under various themes
- Funds for programs are provided by MPA and Singapore Maritime Cluster Fund
- Themes include digital transformation, legal, insurance, technical safety and security and environmental, young executives

The MPA has developed a decarbonisation roadmap to transition to low/zero carbon energy sources by 2050. It has also established a dedicated R&D hub to build technology for decarbonisation.

The Port of Singapore has tested the use of driverless trucks. The autonomous electric vehicles being implemented help in introducing sustainable solutions.

Global transshipment ports such as Singapore have built mega structures to accommodate large mainline vessels.

The Port of Singapore outsources pilotage and towage to third-party service providers. The Port Authority of Singapore has created a one-stop port clearance portal for streaming regulatory transactions.

MPA has developed a Maritime Centre of Excellence for R&D capabilities in strategy

- Next-generation ports in association with National University of Singapore
- Maritime Energy and Sustainable Development in association with Nanyang Technological
- Centre of Excellence in Maritime Safety in association with Singapore Polytechnic

Conclusion

The white paper has analysed the current state of India's ports and the opportunities they present to adopt innovative technologies and practices to promote economic growth and reduce environmental impact. The government's focus on port-led development, as evident from initiatives such as Sagarmala, provides the impetus to embrace modern approaches to port management.

The white paper identified the areas that are crucial to creating smart, safe, and sustainable ports. Port automation has emerged as a vital factor that could significantly enhance operational efficiency, safety, and competitiveness while reducing human error and costs. Adopting smart technologies, such as automated container-handling systems, can offer great value to customers and enhance the overall port experience.

Digitalisation is another key contributor to this overhaul. By leveraging data analytics, cloud computing, and blockchain technologies, India's ports can enhance transparency, accountability, and collaboration across the maritime ecosystem. This, in turn, can optimise port operations and reduce waste while improving safety.

Green energy is a critical and highly promising field for domestic ports. As highlighted in the white paper, India intends to increase the share of renewable energy to 60% of the total power demand of each of its major ports, which is currently less than 10%. This can be achieved through use of solar- and wind-generated power and can help India move towards a circular economy while reducing its carbon footprint.

The final key area is workforce development. By investing in skill development and training programs, India can equip its maritime workforce with the necessary knowledge and expertise to operate and maintain the latest technologies and practices. This can help create a culture of innovation and continuous improvement, which is vital for the long-term success of India's maritime sector.

In conclusion, by adopting modern technologies and best practices, India can create a resilient and competitive maritime ecosystem that benefits all stakeholders and contributes to sustainable development goals.

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