‘‘A Comparative Study On Ports of Rotterdam, Shanghai With JNPA & Mundra Port”

A dissertation submitted to the School Of Maritime Management, Indian Maritime University in the partial fullment of

Master of Business Administration
in
International Transportation and Logistics Management

By

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UNDER THE SUPERVISION AND GUIDANCE

OF

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(A Central University under the Ministry of Ports, Shipping and Waterways)

CHENNAI CAMPUS

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SCHOOL OF MARITIME MANAGEMENT
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Certificate

This is to certify that the project report titled **"A Comparative Study On Ports Of Rotterdam, Shanghai With JNPA & Mundra Port**" is a bonafide work done by **Gangothri N (Reg.No:- 2103305017)** in partial fulfilment of the requirement for the award of the degree ofMaster of Business Administration in Indian Maritime University, Chennai.

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External Examiner :-

Place : Chennai

Date :...../. ...../202

DECLARATION

I, **Gangothri N,** do hereby declare that the dissertation entitled **"A Comparative Study On Ports of Rotterdam, Shanghai With JNPA & Mundra Port"** is exclusively a bonafide work done by me under the supervision and guidance of **Dr. Emil Mathew**, Assistant Professor, School of Maritime Management and is submitted to Indian Maritime University inpartial fulfilment of the requirement for the award of the degree of Master of Business Administration.

I further declare that no part of this report has been previously submitted to any other university or academic body for the award of any degree or diploma.

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The dissertation entitled **"A Comparative Study On Ports osf Rotterdam, Shanghai With JNPA & Mundra Port"** has been done under the supervision and guidance of **Dr. EmilMathew**, Assistant Professor, School of Maritime Management, Indian Maritime University and I express my sincere gratitude to her for the inspiration and guidanceshe has given for the accomplishment of this work.

With great pleasure I acknowledge the help given to me by my family members and my friends .

SPlace : Chennai Date :...../...../2023

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ABSTRACT

A digital port is a smart port. Being "smart" in a competitive sense involves being more appealing and inventive. A smart port provides workers with the knowledge and tools they need to address the organization's particular internal and external problems, as well as to speed up the transportation of goods, the provision of services, and the seamless flow of information. The Smart Port uses a comprehensive strategy to achieve outcomes without posing additional problems for itself or other parts of the supply chain eco-system. By enhancing port sustainability, economic efficiency, and capacity to handle rising port traffic, these ports use smart technology solutions to boost efficiency, effectiveness, and security.

The Internet of Things (IoT), Big Data, Blockchain, Artificial Intelligence (AI), and Drones are some of the key technologies that Smart Ports employ to act as ports specifically designed for managing cargo. Smart Ports also use automation, service integration, digitalization, and data-driven strategies. augmented reality and other intelligent interfaces based on data science.

The comparison between smart ports and Indian ports is the focus of this study. In this study, we learned what a smart port is and about the five biggest smart ports worldwide. In addition, the technology employed in smart ports, their advantages, different generations of ports, and a comparison of four ports (two smart ports and two Indian ports) are discussed.

CHAPTER 1

INTRODUCTION

1.1Introduction

In terms of the Indian subcontinent, shipping is crucial to the transport sector of the country's economy. Almost 95% of the nation's trade is transported by sea in terms of volume (70% in terms of value). Indian Shipping Companies India's maritime industry benefits from two geographical features, namely its 7,500 kilometres of extensive coastline. India is a possible location for shipping and transhipment in the future due to its about 7517 kilometres of coastline, 12 large ports, and 187 minor ports. It has administrative relevance to divide Indian ports into major, small, and intermediate categories. Maritime transportation is included on the "concurrent list," which is governed by both the Central and State governments, in accordance with the federal framework and the country's constitution. The nine coastal states' relevant departments or ministries are in charge of managing the minor and intermediate ports, while the Central Shipping Ministry oversees the major ports. The second is its advantageous location alongside the majority of the main maritime roads.

A smart port is a port that utilizes advanced technologies and innovative practices to improve its operations, efficiency, and sustainability. Smart port initiatives aim to increase port productivity, optimize supply chain management, enhance customer experience, and reduce environmental impact.

There are several parameters that can be used to define a smart port. These include:

- Digitalization: A smart port should leverage digital technologies to improve port operations and supply chain management. This may include using big data analytics, Internet of Things (IoT) devices, automation, and artificial intelligence (AI).
- Connectivity: A smart port should be well-connected to other modes of transportation, such as rail and road, to ensure efficient movement of cargo.
- Sustainability: A smart port should adopt sustainable practices to reduce its environmental impact. This may include using renewable energy sources, reducing carbon emissions, and implementing waste management programs.
- Innovation: A smart port should be innovative and continuously seek new ways to improve its operations, customer experience, and sustainability.

- Collaboration: A smart port should foster collaboration among stakeholders, including port operators, shipping lines, logistics providers, and government agencies.
- Customer-centricity: A smart port should focus on providing a seamless and efficient experience for customers, including streamlined processes, real-time tracking, and effective communication.

Rotterdam and Shanghai are two of the world's busiest and most advanced ports, known for their extensive use of innovative technologies and smart port concepts. Analyzing the features and benefits of these ports can provide valuable insights into the future of port operations and logistics.

Rotterdam, located in the Netherlands, is the largest port in Europe and the fourth-largest port in the world. It handles more than 14,000 seagoing vessels and 140,000 inland vessels annually. Rotterdam's success can be attributed to its strategic location, state-of-the-art infrastructure, and its focus on innovation and sustainability.Rotterdam's smart port initiatives include a variety of innovative technologies and practices aimed at improving efficiency, safety, and sustainability. For example, the port uses digital twins, which are virtual replicas of physical assets and processes, to optimize operations and prevent disruptions. Rotterdam also uses blockchain technology to improve transparency and security in supply chain transactions.

Shanghai, located in China, is the busiest container port in the world, handling more than 43 million twenty-foot equivalent units (TEUs) in 2020. Shanghai's success can be attributed to its strategic location, extensive transportation network, and its focus on innovation and technology.Shanghai's smart port initiatives include a variety of advanced technologies and practices aimed at improving efficiency and productivity. For example, the port uses artificial intelligence (AI) to optimize operations and reduce wait times for ships. Shanghai also uses Internet of Things (IoT) technology to track containers and improve supply chain visibility.

The benefits of analyzing Rotterdam and Shanghai as smart ports are numerous. By studying their innovative technologies and practices, we can gain valuable insights into the future of port operations and logistics. We can learn about the benefits of using digital twins and blockchain technology to optimize operations and improve transparency in supply chain

transactions. We can also learn about the benefits of using AI and IoT to improve efficiency and productivity.

Jawaharlal Nehru Port Authority (JNPA) and Mundra port, both located in India, are two of the largest and most significant ports in the country. Comparing these ports with Rotterdam and Shanghai can provide insights into the similarities and differences in port operations and logistics between developed and developing countries.Comparing JNPT and Mundra port with Rotterdam and Shanghai can provide insights into the similarities and differences in port operations and logistics between developed and developing countries. For example, while Rotterdam and Shanghai are among the world's most advanced and innovative ports, JNPT and Mundra port face challenges related to outdated infrastructure and regulatory frameworks.

Comparing these ports can also highlight the importance of technology in the port industry, particularly in developing countries where environmental regulations may be less stringent. By studying the technology measures implemented by Rotterdam and Shanghai, JNPT and Mundra port can gain insights into the benefits of using digitalization and increase port productivity.

1.2 Objectives of the Study

- Comparison of annual cargo handling in tonnage and TEUs, Number of berths, Quay length ,equipments used to handle cargo.
- To understand the level of automation and digitization in smart ports compared to Indian ports
- To understand the role of smart technologies in enhancing the safety and security of ports and reducing operational costs.
- To understand quality management systems in smart and Indian ports.
- To explore best practices from smart ports that can be adapted to Indian ports to improve their performance.

1.3 Limitation of the Study

- The study is purely based on secondary source of data.
- The information and data may not be accurate.
- Due to Covid-19 and this pandemic situation there were several hurdles for collection of data.

1.4 Methodology of the Study

- Data Collection: The data and other required details collected for this research is purely from secondary sources. Various articles, reports and websites were searched for the collection of the data related to the study.
- From the offical website of Rotterdam Port, Shanghai Port, Jawaharlal Nehru Port Trust, and Mundra Port

CHAPTER 2
LITERATURE REVIEW

2.1 Literature Review

In this study, Indian ports and smart ports are compared. The digitalized and automated ports are referred to as smart ports. In comparison to regular ports, these ports operate more efficiently and with greater performance. The development of the sixth generation of ports coincides with their full automation, digitization, and high level of security. This research utilises a number of papers on smart ports as references.

Anahita Molavi, Gino J. Lim wrote an article titled **"A Framework for Building a Smart Port and Smart Port Index".** The several generations of ports were covered in this article, and this study aims to create a framework for a smart port as well as a numerical metre, the Smart Port Index (SPI), that ports may utilise to increase their sustainability and resiliency. On Key Performance Indicators (KPIs) acquired from the literature, their suggested SPI is built. The operations, environment, energy, and safety & security KPIs are arranged around the four major activity categories of a smart port. The performance of some of the busiest ports in the world is evaluated through case studies, which demonstrate how SPI may be used.

UN ESCAP published a report on **"Smart Ports Development Policies in Asia and the Pacific (February 2021)".** In this study, the development plans for ports and terminals as well as smart ports were discussed. Smart ports provide the port sector the ability to communicate with outside companies more accurately, openly, and transparently, improving partnerships and operational effectiveness. Major ports are becoming more digitalized thanks to connection between autonomously operating systems, improvements and expansions to current information systems, and the creation of stakeholder communities. Robots, artificial intelligence (AI), and digital twins used in port facilities or equipment reduce human-to-human contact. Instead of using the most recent innovations, smart ports are created by connecting a variety of information technologies and systems. This requires information

integration, system convergence, and connections between individual systems, equipment, facilities, and commercial entities as well as cooperation and partnership among stakeholders.

A. Karaś (Gdynia Maritime University, Gdynia, Poland) wrote an article on **"Smart Port as a Key to the Future Development of Modern Ports"**. The creation of "Smart Ports" is made possible by technological advancements. Determining which technologies to use and how to deploy them, though, continues to be difficult. The article's study question is: Does the ongoing introduction and application of the idea of intelligent ports represent an unstoppable trend that is dictating the course of development for contemporary seaports? The article's other goal is to assess new initiatives being implemented in ports throughout the North and Baltic Seas that are progressively applying the idea of a smart port.

Subhodeep Ghosh | In: Marine Technology wrote an article on **"What Are Smart Port Technologies?".** The smart port technologies and essential standards for ports and terminals were covered in this article. This article made mention of automation, data utilisation, and other relevant subjects.

For the purpose of gathering the information and facts needed for this study, several additional papers and websites were also consulted. The official websites of the Port of Rotterdam, the Port of Shanghai, the Jawaharlal Nehru Port, and the Port of Mundra were all utilised as sources of information. Additionally, several smart port-related websites were recommended for gathering data and information to help the research.

CHAPTER 3

DETAILS OF PORTS

3.1 Ports of Rotterdam

History

At the mouth of the Rotte River, a small fishing community was established in 1283 after a section of land was reclaimed. After a canal to the Schie was built, the port developed into a significant seaport in 1360. ThisGrowth gave the port access to the larger northern cities and facilitated the movement of goods between Germany and England. After its expansion along the Meuse, the Port of Rotterdam rose to become the second-most significant port in the nation.

When the sea route to the Indies was discovered in the 17th century, the shipping and commercial sectors experienced a boom. From 1795 to 1815, the port was under French rule, which significantly decreased traffic. Following Napoleon's defeat, trade picked back up. When Germany attacked the port in 1940, over one-third of its facilities were destroyed. After World War II, the port began its reconstruction process. Modern-style buildings were erected in place of the ancient traditional structures that were destroyed during the war.

Port operator

The Port of Rotterdam Authority (PoRA) oversees and runs the port and industrial region of Rotterdam. It is a non-listed public limited company, and the Dutch State owns 25% of the shares, with the Municipality of Rotterdam owning the remaining 75%. The port authority is in charge of managing maritime traffic as well as creating new port sites, public infrastructure, and port districts. The company's major objective is to improve the port's competitive position in terms of size and quality.

Design and construction

The Port of Rotterdam has an area of 10,500ha, of which 5,300ha are industrial areas, while the remaining 3,300ha are made up of infrastructure and sea surface. The port is 40 km in length and its quay is 89 km long. Additionally, the port has 1,500 km of pipelines.

In 1877, a railway over the Meuse River allowed access to the Port of Rotterdam for the southern Netherlands. Additionally, some bridges were constructed in 1890 to allow for the expansion of a bigger harbour on the river's south banks.

One of the largest dredged harbours in the world is the Waal Harbour in Rotterdam, which was constructed between 1906 and 1930. The Europort complex was built along the mouth of the Nieuwe Waterweg, significantly expanding the port's harbour area.

As the current port is anticipated to fill up by 2014, work on the Maasvlakte 2 harbour began in 2008. In 2013, this harbour anticipates a ship's inaugural anchoring. A contracting partnership called PUMA (Project Uitbreiding Maasvlakte) was awarded the contract for building the first Maasvlakte 2 facility. Van Oord and Koninklijke Boskalis Westminster make up the consortium. The group will also be in charge of five years of seawall maintenance. Maasvlakte 2 will be financed by the Port of Rotterdam Authority.

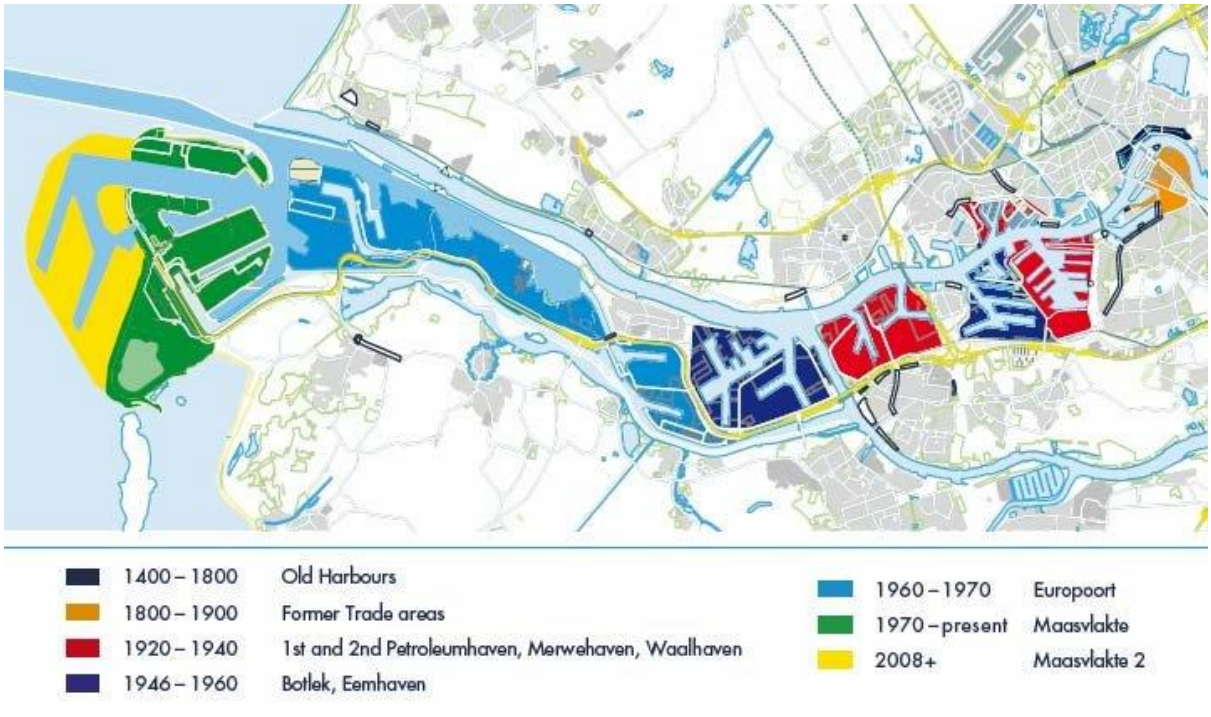


Figure 3.1 - Layout of Port of Rotterdam

3.2 Port of Shanghai

History

In 1297, the Yuan Dynasty officially recognised the Port of Shanghai, which had previously existed as Shen or Hudu between the fifth and seventh centuries AD. The Quing Dynasty granted permission for oceangoing vessels to use the port in 1684. This allowed the port to collect customs duty for all foreign trade, and by 1735 it had grown to be the most important seaport in the Yangtze basin.

Under the terms of the Treaty of Nanjing, the port was made open to international trade in 1842. Following the Treaties of the Bogue in 1843 and the Sino-American Treaty of Wangsai in 1844, it became more approachable when foreign nations were released from domestic laws and regulations.

Port Operator

The management and operation of the port's public terminals is the responsibility under Shanghai International Port Group (SIPG). International, national, and domestic freight transportation is handled by SIPG. Along with building, managing, and running port facilities, it is also in charge of maintaining, producing, and leasing containers.

Design and construction

The Port of Shanghai's three primary container port sections are Wusongkou, Waigaoqiao, and Yangshan. The container terminals include 156 quay cranes, 43 berths, and a quay length of almost 13 kilometres. Yangshan Deepwater Port was built in four phases since there wasn't enough water depth on the port's mainland. The deepwater port, which is in the East China Sea, is 32.5 kilometres from the mainland and 30 kilometres away from it.

Phase I terminal, which was opened in December 2005, was completed at an investment of $7.5bn. The terminal operates at a water depth of 16m and has five berths. In the first year of its construction, the terminal handled 3.1 million TEU.

Phase II of the terminal was built with an investment of $7bn and opened for operation in December 2006. The terminal, which is capable of handling 2.1 million TEU, uses four berths.

Phase III began its operations in 2008.

Phase IV of the terminal commenced its operations in December 2017. It is the world's largest and advanced automated container terminal, which handled two million TEU in its first year of operation.

Shanghai Container Terminals Company (SCT), a partnership between Hutchison Port Holdings Limited (HPH) and SIPG, oversees the Wusongkou region. The three container ports run by SCT are Zhanghuabang Terminal, Jungong Road Terminal, and Baoshan Terminal. The firm offers inland commodities storage, container cleaning and maintenance, storage and transit, and electronic data interchange.

Shanghai Pudong International Container Terminals, SIPG Zhendong Container Terminal Branch, Shanghai East Container Terminal Company, and Shanghai Mingdong Container Terminals Limited are the companies that run the Waigaoqiao region. Shanghai Pudong has 147 pieces of equipment and machinery for handling containers, 36 RTG, 10 quay cranes, 73 container vehicles, and 11 forklifts. It also works on 500,000 square metres. Transport, storage, and management of containers are made easier by Shanghai Mingdong. With the help of 120 RTG and 34 container quay cranes, the port operates. The terminal has a 2.2 million TEU capacity for containerized freight. Non-container terminals that are located on the Huangpu River help the port as well. These terminals serve as distribution hubs for the port's remote districts and aid in the Yangtze River Valley's economic growth.

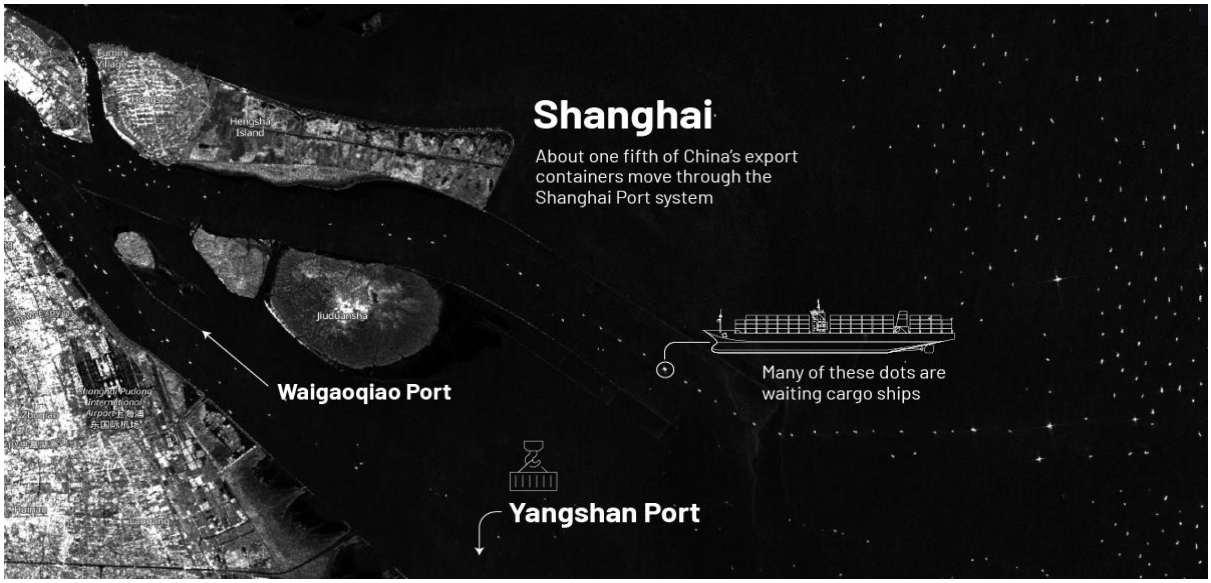


Figure 3.2 - Port of Shanghai

3.3 Jawaharlal Nehru Port

History

The port opened on May 26, 1989. The largest container port in India is Jawaharlal Nehru Port (JNPT) or JLN Port, also known as Nhava Sheva Port. It handles about 55% of the country's containerized cargo and has consistently exceeded the historic milestone of 4 million TEUs (Twenty-foot Equivalent Units) in containers over the past five years. This port on the Arabian Sea is situated east of Mumbai in the Raigad district of Navi Mumbai and is reached through Thane Creek. It is a Navi Mumbai nodal city. Its popular name is derived from the names of the nearby villages of Nhava and Sheva. The Western Dedicated Freight Corridor's (now under construction) terminal is also located at this port. Among the top 100 container ports in the world, JNP is placed number 28.

The first privatised container terminal in India, NSICT, opens in 1999–2000. And in 2001, JN Port became the first port in India to handle one million TEUs or more. The addition of two more terminals, namely the 330M Stand-alone Container Terminals (DP World) and the 4th Container Terminal (Port of Singapore Authority) and a Satellite Port at Vadhvan Point, will enable JNP to reach its long-term goal of 10 million TEUs by the years 2020–21. This will open up a number of valuable opportunities for the maritime trade, including shipping lines and shippers, to transport their cargo to various sectors around the world.

Design and Construction

JNPT is in charge of running the JNP Trust (JNPT) Container Terminal. It has three berths along its 680 m (2,230 ft) long quay. An organisation led by P & O, currently a division of DP World, has a lease on the Nhava Sheva International Container Terminal (NSICT). It was put into service in July 2000 and has a quay length of 600 metres (2,000 feet) with two berths. It has a 62.15 million tonne freight carrying capacity. India's first privately run container terminal was called NSICT. A third container port run by APM Terminals, GTI (Gateway Terminals India Pvt Ltd), was opened in 2006 and has the ability to accommodate 1.3 million TEUs. By July 2016, a brand-new independent container terminal known as NSIGT with a 330-meter quay and a 12.5 million tonne capacity will be fully operating. Bharat Mumbai Container Terminals (BMCT), the fourth container terminal, will be built and run by PSA International. Phase 1, which has a 2.4 million TEUs per year capacity, was finished in December 2017. By the end of Phase 2, the terminal will have a quay length of

2,000 metres and a maximum capacity of 4.8 million TEUs per year. The port has a footprint that is 22.70 square kilometres . The Jawaharlal Nehru Port Trust Influence Area (JNTPIA), which encompasses an area of 187.01 square kilometres, includes the JNP.

JNP has a fully functional Custom House, 30 Container Freight Stations, and connections to 52 Inland Container Depots located all throughout the nation. Ongoing initiatives include the Dedicated Freight Corridor (DFC), which will enhance the current train capacity of 27 to 100 trains per day; Multi-Modal Logistics Park (MMLP); and development of the Port road link are strengthening the hinterland connectivity by rail and road. The Port has an advantage over other ports in that it is close to airports, hotels, exposition centres, and other facilities as well as the cities of Mumbai, Navi Mumbai, and Pune.

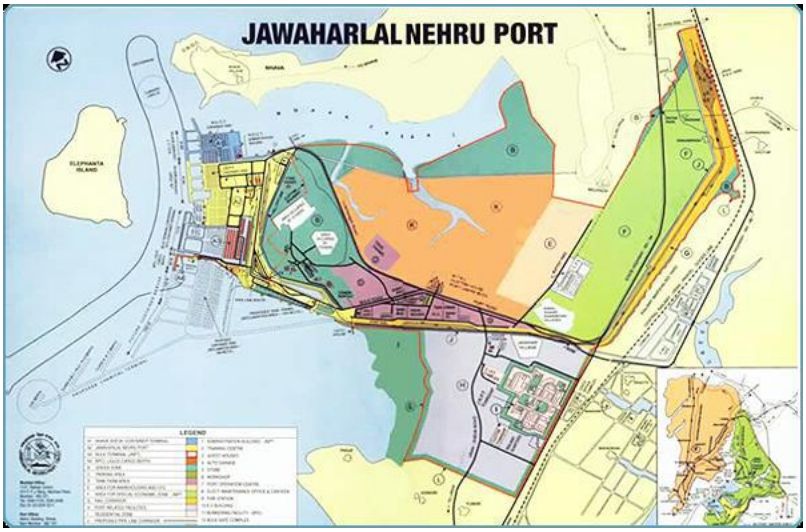


Figure 3.3 - Layout of JN Port

3.4 Mundra Port

History

A private port and special economic zone, the Port of Mundra. The business was established in 1998 as Gujarat Adani Port Limited (GAPL), and it started operations in 2001. Mundra Port and Special Economic Zone Limited was the new name of the merged corporation. The installation of a captive jetty at the Port of Mundra received approval from the Gujarat Maritime Board (GMB) in 1994. The Gujarat Adani Port Ltd., a joint-sector business, was established in 1998, and multipurpose berths 1 and 2 at Terminal I went into service at the

same time. The first ship to be moored was MT Alpha-2, a small tanker, on October 7, 1998. Multi-purpose berths 3 and 4 at Terminal I were inaugurated in 1999. The Port of Mundra and GMB entered into a concession deal in 2001 for the construction, management, and upkeep of the Mundra port.

In order to handle crude oil in the port, Guru Govind Singh Refineries Ltd. inked a contract with the Port of Mundra in 2002. Additional contracts with Indian Oil Corporation Limited were signed in 2002 to develop a single-point mooring facility and manage crude oil at Mundra. A sub-concession agreement for the addition of a container terminal to the Port of Mundra was completed in 2003, and the facility started operations the same year.

Gujarat Adani Port Limited and Adani Port Limited amalgamated in 2005. The single-point mooring was put into use in late 2005. Founded in 2003, the Mundra Special Economic Zone. It became the first port-based special economic zone in India for several products. For the handling of bulk cargo, two additional berths at Terminal II became active. A cargo train with two stacks got going. In 2006, Gujarat Adani Port Ltd., the Mundra Special Economic Zone Ltd., and Adani Chemicals Limited combined to become the Mundra Port and Special Economic Zone Limited (MPSEZ).

At Terminal II, two more berths for bulk cargo were installed in 2007, and terminal trial run operations started. To generate electricity for managing coal cargo imports, a service contract was struck with Tata Power. The public and staff were issued equity interests in MPSEZ in 2007, and these shares were also listed on the Bombay Stock Exchange and the National Stock Exchange. 2008 saw the signing of a service contract with Maruti Suzuki India Ltd. to manage vehicle exports. On January 6, 2012, MPSEZ increased the scope of its port activities and changed its name to "Adani Ports and Special Economic Zone Limited" (APSEZ). The port is a stop along the Maritime Silk Road, which connects the Mediterranean coast of China with Central Europe and the North Sea via the Upper Adriatic.

Design and Construction

Large ships, particularly capsized ones that are fully loaded, can dock alongside its berth thanks to the port's wide draught. Mundra Port includes places for storing different types of goods. For storing import or export goods on port property, the port contains 3,150,000 square metres of open storage yards and 2,25,000 square metres of closed godowns. The 97 tanks that make up the ASPEZ Liquid Terminal, which can store a total of 4,25,000 kiloliters of liquids, are of different sizes and shapes.

A suitable infrastructure for cargo evacuation has also been created at Mundra Port with the inverted funnel design in mind. The idea is that a port's evacuation infrastructure should have a higher capacity than its maritime infrastructure. Mundra Port has created infrastructure for handling, storing, and evacuating cargo that is tailored to certain commodities. A facility for handling fertilisers is called the Fertiliser Cargo Complex (FCC). The FCC has 2 operational lines with 44 bagging machines with a capacity to bag 660 nos. of 50-kg bags per minute and a capacity to load and evacuate 8–10 rakes per day i.e., 25,600 tonnes per day.

The 1,20,000 square metre steel yard has equipment for handling steel freight and is a space for storing steel. Eight Goliath cranes, two mobile cranes with vacuum lift attachments, six forklifts with a variety of attachments for handling steel coils, slabs and plates, one reach stacker and sixty trailers are all provided for internal transportation in the steel yard.

A sizable land area is available for development in addition to the port area. This region has now been designated as a SEZ and is operational. It is the largest port-based multi-product SEZ in the nation. The hinterland of north and northwest India, which accounts for two-thirds of India's GDP, is best served by this SEZ. The region is connected to the national pipeline, rail, and road networks. The port, container terminals, train, airport, container goods station, and storage tanks are all distributed across an area of 84 km2.

The maritime infrastructure at Mundra Port has ten berths for handling dry bulk and break bulk cargo, three berths for handling liquid cargo, six container berths, one of which is a Ro-Ro berth, three berths for mechanised import cargo, and two single point moorings for importing crude oil. Other berths can accommodate vessels with a maximum draught of 17 metres, while the mechanised import cargo berths can accommodate vessels with a maximum draught of 19 metres. The SPM facility provides a 32-meter draught.

Pilots and tugs are all owned and operated by the port. In order to do capital and maintenance dredging tasks, Mundra Port also possesses a fleet of dredgers, guaranteeing that it has the deepest draught among all Indian ports. The largest coal importing terminal in the world is located at Mundra Port. It has a yearly capacity of 4 crore (40 million) tonnes of coal. It was constructed at 2,000 crore (280 million US dollars).

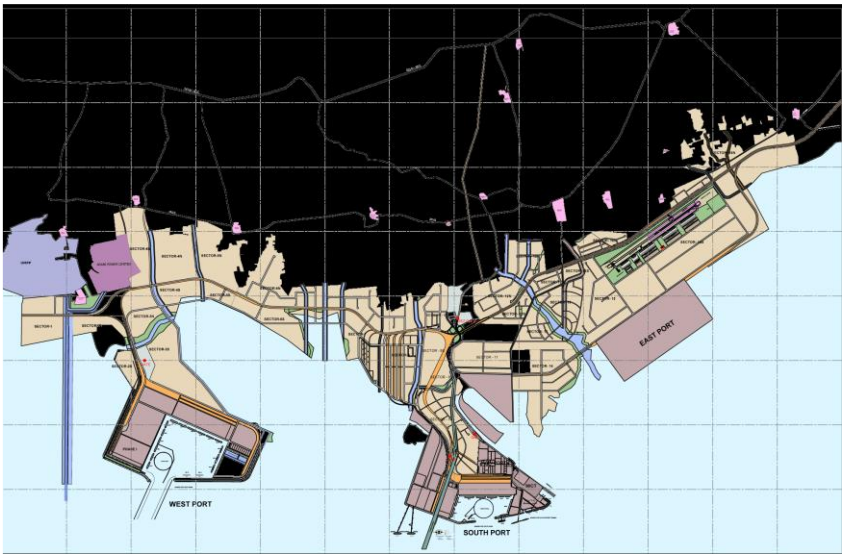


Figure 3.4 - Layout of Mundra Port

3.5 Fundamental Benchmarks for Ports

Infrastructure:

The most important factor in choosing a facility of this type is obviously this. The size of the port or terminal, the amount of cargo it can handle, the number of vessels it can load or unload, and other features that make it possible to maintain for seamless handling of logistics in low downtime also endowing on the expansion of its business with rising demand-supply. It is essential to have the right equipment, but it is also important that it be able to handle enormous volumes. An advantage over a port with 100 or 200 Tonnes of cranage is always held by one with 500 Tonnes. The advantages of a container terminal with measures for processing bigger TEU containers over one with lower restrictions are several. A facility's and its infrastructure's overall competency is directly correlated to the amount of investment made in it. However, this only falls short. For a port to operate well, it is desired that the resources be used effectively, there be reduced downtime, high quality standards, and most importantly, safety.

Traffic:

Ports experience heavy internal and exterior or intermodal traffic. For unfettered efficiency, a competitive port facility must provide both of these requirements. The maritime traffic caused by ships travelling in and out for the purpose of loading and unloading goods is, of course, external. The intermodal refers to movement of commodities between a facility and other locations using trucks, trailers, trains, carriages, and other localised transportation

methods. One's delay has an impact on another. At the same time, everyone's delays have an impact on how well the entire system functions.

Quality:

One of the pillars is quality assurance, just as in any other firm. Quality includes many different aspects, such as handling cargo properly and safely, maintaining the standard functionality of parts and equipment, keeping cleanliness and hygienic conditions, arranging and stowing goods in a systematic manner, etc. The ISO 9000 divisions' Quality Management criteria must be rigorously upheld.

Safety:

This type of infrastructure's most basic component may also have the highest risk and hazard index. Regular machinery and equipment safety inspections, staff training, provision of suitable and certified protective measures, and promotion of knowledge of safety measures and their application are essential. The current pandemic has caused major ports to create more stringent procedures for the present and future. Health is another important issue in this. The adoption of the ISO 45000 family, which takes occupational health and safety into account, is being accelerated at unimaginable rates by practically all major ports and terminals worldwide.

Location and Expansion:

Last but not least, irrespective of everything mentioned before, this is relevant to all types of infrastructure. For a very long time, ports have been attempting to optimise the business- and expansion-friendly site while also taking into account other aspects such as land availability, accessibility, demography, economics, climate, geography, etc. Following all of the aforementioned guidelines is important after this standard has been set. Based on availability and need, locations can take many different forms. Some of the typical types include bays, estuaries, deltas, and riverine ports.

Security:

Even while it may not seem to matter to how these facilities operate or their overall results, this is fundamentally connected to every detail. Security can include a variety of things, including the safety of people, equipment, and freight (ISO 27000), as well as systems, cybersecurity, and data.

3.6 Smart Technologies/Aplications in Smart Ports

Big Data in the Shipping Industry:

Large data sets will be available to the shipping sector so that it may enhance its operations and become port-smart. According to Marine Digital, big data is utilised to manage the sensors on a ship and do predictive analysis, both of which are essential to avert delays and boost operational efficiency across the board. Maintaining the necessary security and privacy in the shipping sector requires accurate cargo tracking.

For decades, traditional technology has met the analytics demands of businesses, enabling them to evaluate big data sets from traditional sources like warehouse and distribution systems. It advances to a new level with big data. It will make it possible for businesses to more cost-effectively access large amounts of data, including non-traditional data formats like text, audio, and video, in addition to data from business systems, in batch and real-time modes. Large data quantities are used by big data. Whether you are receiving the items as a customer or a vendor, this information is crucial.

Artificial Intelligence (AI):

Machine learning, or artificial intelligence, is the process through which computers are taught to copy and emulate human decision-making and monitoring procedures. Business processes and efficiency are improved by artificial intelligence. It may be applied as a method for making informed decisions on predicted port operations. Big data is used by artificial intelligence to forecast future events in the supply chain system. Additionally, the use of artificial intelligence improves workplace safety by lowering driver error and accident rates as well as overall workplace security.

Machine learning, or AI, is the term most often used to describe how computers learn. In other words, computers use algorithms that get better over time. AI may be used, for instance, to improve shipping routes in the shipping sector. AI is capable of choosing the fastest and best path.

Internet of Things (IoT):

The Internet of Things (IoT) is a network of "things" with embedded technology, such as sensors. "Wired and wireless networks connect sensors and actuators embedded in physical objects." The Internet of Things, for instance, can precisely identify what each ship is

carrying. IoT enables port authorities to monitor cargo and track arriving ships in real-time. Decisions may be made using real-time data thanks to IoT.

The shipping sector hopes to benefit from the Internet of Things in a number of ways, including reduced operational costs, real-time cargo tracking and monitoring, and more. As a result of data insights made possible by IoT connectivity, ports will become "smart."

Blockchain Technology:

For the transportation sector, blockchain technology may prove to be a potent instrument. It should be compatible with other technologies like big data, automation, and the Internet of Things. Data is kept through blockchain technology. This information is permanently saved and cannot be removed. All data may now be saved online thanks to blockchain technology, which might completely change how transportation companies make decisions. The reason being that the sector would have access to unalterable real-time data. Blockchain technology might speed up and enhance the efficiency of shipping, as well as data visibility and demand management, if the logistics sector embraces it. The advantages of blockchain technology are innumerable and include reduced costs, faster processing times, and improved customer service.

Drones:

The use of drones in the ports and logistics sector is steadily spreading. Drones are being used by ports in routine monitoring to increase safety, cut costs, and boost process effectiveness. Airobotics drones are being used by ports all over the world, from the Netherlands to Vietnam, to monitor ships, regulate aerial freight movement, clean up the surrounding area, and monitor port building.

High Bay Storage (HBS) System:

The High Bay Storage (HBS) system is an automated container handling system that stacks containers up to 11 floors high. It offers more than three times the capacity of a conventional yard and offers improved performance, including notable improvements in handling speed, energy efficiency, safety, and operating costs.

In order to minimise the amount of land required to support terminal operations by at least 70% and boost annual yard throughput per hectare by more than 300% compared to a Rubber Tyred Gantry Crane (RTG) container yard, DP World has started the BoxBay (a high bay storage system) pilot phase.

CHAPTER 4

ANALYSIS

Ports are critical nodes in global supply chains, serving as gateways for the movement of goods from one country to another. Rotterdam, Shanghai, JNPT (Jawaharlal Nehru Port Trust), and Mundra Port are all significant ports that play a vital role in international trade. These ports vary in terms of their location, size, cargo handling capabilities, and technological advancements. In this comparative analysis, we will examine and compare these four ports in terms of their annual cargo handling, infrastructure, and technological advancements. By comparing the strengths and weaknesses of each port, we can gain insights into how they are competing in the global market and identify potential areas for improvement. This analysis can be useful for businesses, investors, and policymakers seeking to understand the strengths and weaknesses of these ports and make informed decisions based on this information.

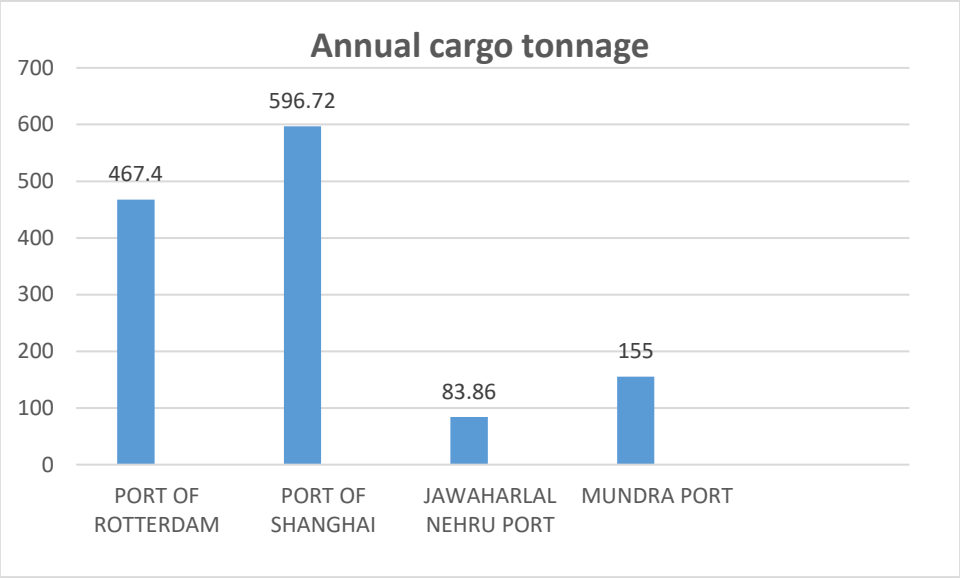
Analyzing ports is a critical process that can help identify areas for improvement, facilitate better decision-making, and promote sustainable development. By examining the key factors that impact their performance, including location, infrastructure, capacity, connectivity, and efficiency, businesses and policymakers can make informed decisions about which ports to use and how to promote their growth and development. Ultimately, a well-analyzed and efficient port system can contribute significantly to economic growth and development while promoting sustainability and social welfare..

4.1 Annual cargo tonnage:

Table 4.1 - Annual cargo tonnage

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
467.4 million tonnes	592.6 million tons	83.86 million Tonnes	155 million tonnes

Figure 4.1 – Graph of Ports v/s Annual cargo in million tonnes



Source: https://www.portofrotterdam.com/en

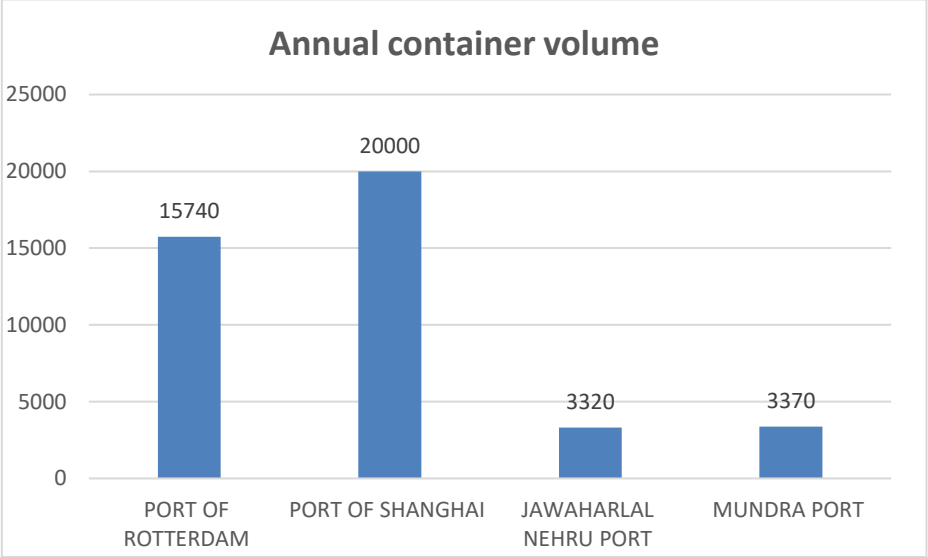
From the above graph it is clear that the annual cargo tonnage of smart ports is greater than the normal ports i.e., Port of Shanghai's (592.6 M Tones) and Port of Rotterdam's (467.4 M Tonnes) annual cargo tonnage is much higher than the Jawaharlal Nehru Port's (63.86 M Tonnes) and Mundra Port's (155 M Tonnes).

4.2 Annual container volume:

Table 4.2 - Annual container volume

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
15.9 million TEU	47.3 million TEU	6.05 million TEUs	6.5 million TEUs

Figure 4.2 – Graph of Ports v/s Annual container in million TEUs



Source: https://en.portshanghai.com.cn/

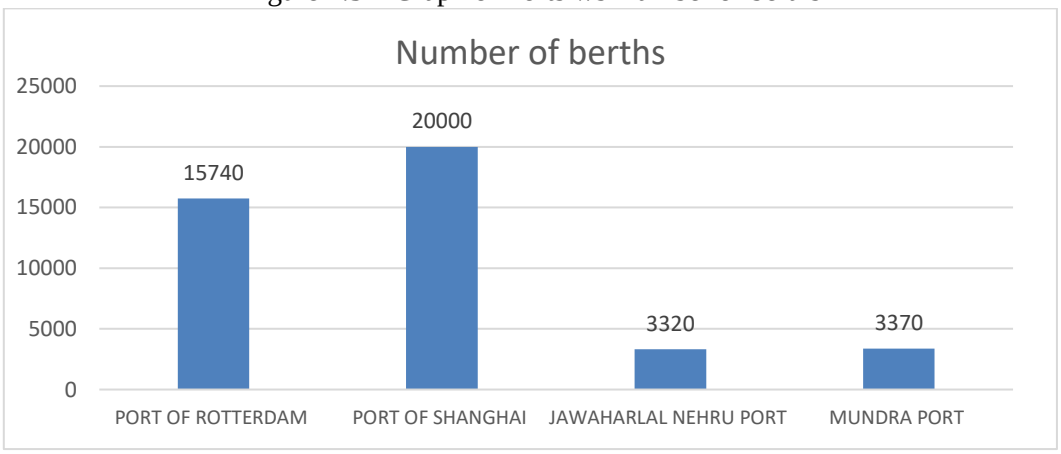
The annual container volume handled by the ports is depicted in the above graph. Compared to the other two ports, Jawaharlal Nehru Port and Mundra Port, the ports of Shanghai and Rotterdam handle a greater volume of containers.

4.3 Number of berths in the ports:

Table 4.3 - Number of berths

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
23 berths	43 berths	12 Berths	24 Berths

Figure 4.3 – Graph of Ports v/s Number of berths



Source: https://jnport.gov.in/

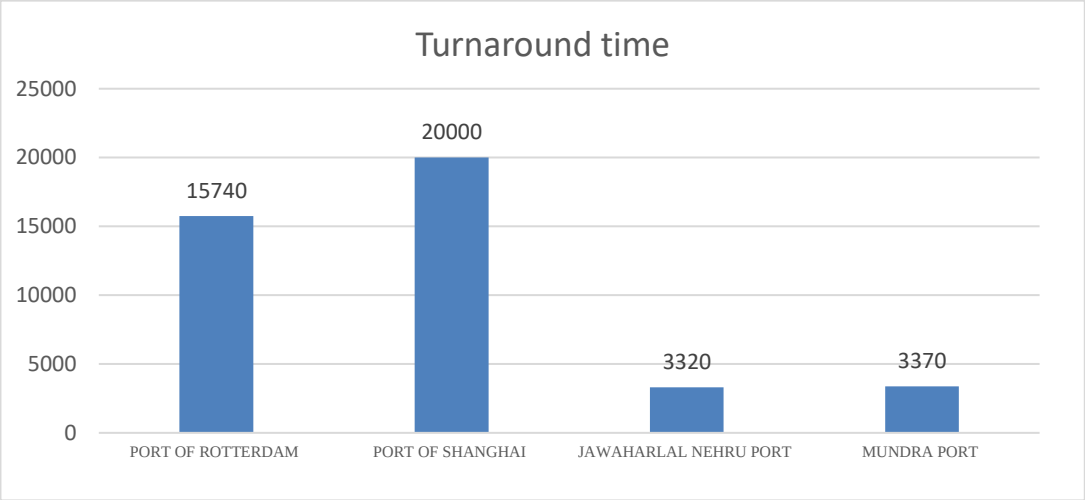
From the above graph we could understand that Port of Shanghai have a greater number of berths as compared to other ports. Mundra Port have 24 berths and Port of Rotterdam have 23 berths. Jawaharlal Nehru Port has the lowest number of ports i.e., 12 berths.

4.4 Turnaround time taken in ports:

Table 4.4 - Turnaround time taken in ports

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
16 hours	23 Hours	67.42 hours	28.47 hours

Figure 4.4 – Graph of Ports v/s Turnaround time in hours



Source: https://origin-webapp.adaniports.com/ports-and-terminals/mundra-port

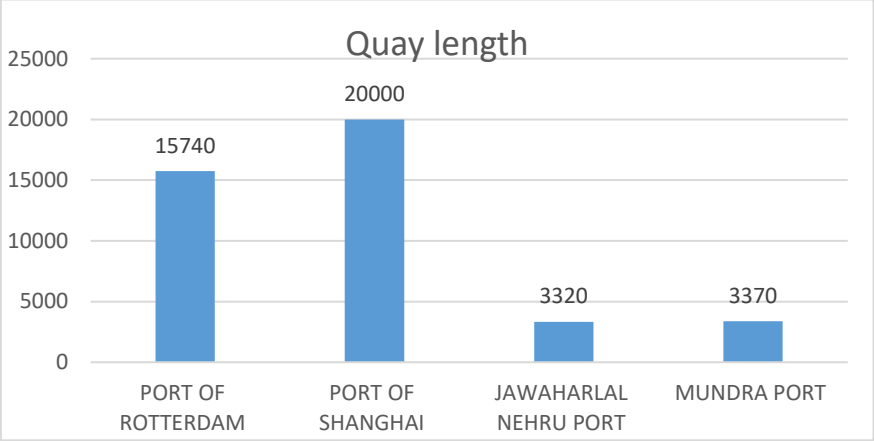
Nehru Port take more turnaround time as compared to other ports that is 67.42 hours. Port of Rotterdam has the lowest turnaround time that is 16 hours. The turnaround time taken in a port depends on port facilities and ships that arrives in the port. Also, the hours or days would differ on the basis of cargo handled.

4.5 Quay length of the ports:

Table 4.5 - Quay length of the port

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
15740 m	20000 m	3320 m	3370 m

Figure 4.5 – Graph of Ports v/s Quay length of the ports in meters



Source: https://jnport.gov.in/

The above graph shows the quay length of the ports. Port of Shanghai's quay have more length as compared to other ports (20000 meters) also the Port of Rotterdam have more quay length i.e., 15740 meters. Jawaharlal Nehru Port and Mundra Port has the least quay length (3320 meters and 3370 meters respectively).

4.6 Equipment used for cargo handling in ports:

Table 7- Equipment used for cargo handling in ports

PORT OF ROTTERDAM	PORT OF SHANGHAI	JAWAHARLAL NEHRU PORT	MUNDRA PORT
13 Quay Cranes	156 Quay Cranes	16 Quay Cranes	28 Super Post Panamax Cranes
21 Super Post Panamax Crane	120 Rubber Tyred Gantry Cranes	11 Super Post Panamax Cranes	2 Post Panamax Cranes
6 Feeder Cranes	11 Forklifts	16 Post Panamax Cranes	95 Rubber Tyred Gantry Cranes
22 Ship to shore bulk cranes	147 Container Handling Equipment & Machineries	116 Rubber Tyred Gantry Cranes	8 Rail Mounted Gantry Cranes
54 Automatic	73 Container Trucks	50 Rail Mounted	10 Reach Stackers

Stacking Cranes		Gantry Cranes	
103 Container Gantry Cranes		27 Reach Stackers	4 Forklifts
50 Automated Storage Cranes		14 Forklifts	
10 Sheer Leg Cranes			
25 Floating Cranes			
50 AGVs			

4.7 Advanced technologies to improve their operation

1. Terminal Operating System (TOS): All four ports use TOS to manage and optimize their container terminal operations.
2. Automated Stacking Cranes (ASCs): All four ports have deployed a fleet of ASCs that help in stacking and retrieving containers within the port premises without the need for human intervention. The ASCs are equipped with sensors and software that enable them to operate autonomously.
3. Quay Cranes: All four ports have installed quay cranes that are equipped with advanced technology, such as remote control, anti-sway systems, and automated positioning systems.
4. Radio Frequency Identification (RFID): JNPT and Shanghai Port have implemented an RFID-based container tracking system that enables real-time tracking of containers within the port premises.
5. Automated Guided Vehicles (AGVs): Shanghai and Rotterdam ports have deployed a fleet of AGVs that help in moving containers within the port premises without the need for human intervention.
6. Internet of Things (IoT): All four ports use IoT sensors and devices to monitor and optimize their operations, including tracking the movement of cargo, analyzing data to improve efficiency, and reducing environmental impact.
7. Digital Twin: Rotterdam Port has created a digital twin of its port operations, which is a virtual replica of the physical port. This helps in simulating and optimizing various scenarios, such as vessel scheduling and cargo handling, to improve efficiency and reduce waiting times.

4.8 Security Measures to ensure the safety of Cargo, Personnel and Facilities

1. Physical Security: All four ports have installed physical security measures such as CCTV cameras, perimeter fencing, and access control systems to restrict unauthorized access to the port premises.
2. X-ray Scanners: All four ports use X-ray scanners to scan containers for contraband goods and other security threats. These scanners can detect any anomalies in containers' contents, allowing authorities to take appropriate action.
3. Automated Identification Systems (AIS): Rotterdam, Shanghai, JNPT, and Mundra Port use AIS to track vessel movements and detect any unauthorized vessels that may pose a security threat.
4. Cybersecurity: All four ports have implemented robust cybersecurity measures to protect their information systems from cyber threats.
5. Port Security Force: All four ports have a dedicated port security force that is responsible for maintaining security within the port premises.
6. Security Checks: All four ports conduct security checks on personnel entering the port premises, including background checks and security clearances.
7. Risk Assessment: All four ports conduct regular risk assessments to identify potential security threats and take appropriate measures to mitigate them.

4.9 Digitalization Initiatives to Improve their Operations

1. Port Community Systems (PCS): All four ports have implemented PCS to facilitate communication and information exchange among various stakeholders, including customs, shipping lines, and freight forwarders.
2. Electronic Data Interchange (EDI): Rotterdam, Shanghai, JNPT, and Mundra Port use EDI to exchange data between different systems, reducing paperwork and increasing efficiency.
3. Internet of Things (IoT): Rotterdam, Shanghai, JNPT, and Mundra ports are using IoT to collect data from sensors and devices to optimize operations, monitor cargo, and improve safety.
4. Blockchain Technology: Rotterdam and Shanghai ports have implemented blockchain technology to increase transparency, security, and efficiency in their operations.

5. Digital Twins: Rotterdam and Shanghai ports are using digital twins, virtual replicas of their operations, to simulate scenarios, optimize operations, and test new technologies.
6. Automated Systems: All four ports have implemented automated systems, such as Automated Guided Vehicles (AGVs), to optimize cargo handling and reduce manual labor.
7. Mobile Applications: Rotterdam, Shanghai, JNPT, and Mundra Port have developed mobile applications for stakeholders to track cargo, monitor operations, and receive alerts.

4.10 Quality management system

1. ISO Certification: Rotterdam, Shanghai, JNPT, and Mundra ports have obtained ISO 9001:2015 certification for their QMS, ensuring compliance with international standards.
2. Quality Control: Rotterdam, Shanghai, JNPT, and Mundra Port have established quality control measures to ensure the quality of services provided by the port, including cargo handling, security, and safety.
3. Customer Feedback: Rotterdam, Shanghai, JNPT, and Mundra Port have established feedback mechanisms to gather customer feedback and use it to continuously improve their operations.
4. Process Improvement: Rotterdam, Shanghai, JNPT, and Mundra Port use process improvement methodologies, such as Lean and Six Sigma, to identify and eliminate inefficiencies in their operations.
5. Training and Development: Rotterdam, Shanghai, JNPT, and Mundra Port provide training and development programs for their employees to improve their skills and knowledge, ensuring the quality of their services.
6. Auditing: Rotterdam, Shanghai, JNPT, and Mundra Port conduct regular audits to ensure compliance with QMS requirements and identify areas for improvement.

4.11 Artificial Intelligence

1. Predictive Maintenance: Rotterdam, Shanghai, JNPT, and Mundra Port have implemented AI-based predictive maintenance solutions to predict equipment failures before they occur, minimizing downtime and reducing maintenance costs.
2. Automated Container Handling: Rotterdam, Shanghai, and JNPT have implemented automated container handling systems using AI, allowing the port to handle containers more efficiently and reduce congestion.
3. Smart Scheduling: Rotterdam, Shanghai, JNPT, and Mundra Port have implemented smart scheduling systems using AI to optimize resource allocation, reducing waiting times for ships and trucks.
4. Predictive Analytics: Rotterdam, Shanghai, JNPT, and Mundra Port have implemented predictive analytics solutions using AI to predict cargo flows, allowing the port to allocate resources more efficiently and reduce congestion.
5. Digital Twin: Rotterdam, Shanghai, JNPT, and Mundra Port have implemented digital twin technology using AI, allowing them to simulate port operations and identify inefficiencies before they occur.
6. Intelligent Surveillance: Rotterdam, Shanghai, JNPT, and Mundra Port have implemented intelligent surveillance systems using AI to monitor the port and detect security threats.

CHAPTER 5

FINDINGS, SUGGESTIONS, CONCLUSION

5.1 FINDINGS

- The Port of Rotterdam and the Port of Shanghai have substantially higher yearly cargo tonnage and container volumes than the other two Indian ports since they are smart ports with far larger capacities and facilities than typical Indian ports.
- The turnaround time required by a ship in a regular port is longer than the turnaround time required in a smart port since smart ports have more extensive port facilities and need less turnaround time.
- The facilities on board the ship and the cargo handled are additional reasons or factors that affect turnaround time. The type of ship is another element that contributes to the longer turnaround time.
- We can witness a wide variety of cargo handling machinery and equipment in smart ports.
- When compared to traditional ports, smart ports have more automated cranes and vehicles.
- Because deploying automated machinery and equipment speeds up the process of handling goods, automated cranes, machines, and vehicles improve port efficiency.
- The port's surroundings and amenities are more better and more modern in smart ports.
- Smart port security and surveillance systems are effective and efficient.
- Big data, IoT, blockchain, AI, drones, and other technologies are employed in smart ports to improve productivity.
- Port automation shortens the time needed to handle shipments and eliminates time that could have been used elsewhere. These hours might be employed for other productive or profitable tasks.
- The fatigue that human labourers experience at the ports won't exist if the machines are automated since they operate nonstop for extended periods of time.
- According to a study comparing smart ports to regular ports, it is evident that smart ports operate more effectively and efficiently than regular ports due to their use of cutting-edge technologies, machinery, security systems, and significant financial investments.

5.2 SUGGESTIONS

- Automation in regular ports has the potential to improve its existing state and increase its effectiveness.
- In order to create a smart port in the future, innovation in port business operations and the use of cutting-edge associated technology are crucial.
- A typical port's productivity and working conditions will improve with the deployment of Artificial Intelligence, the Internet of Things, Big Data, Blockchain, Robotics, Automation, and other technologies.
- Ports must also reduce their carbon impact, enhance air quality, and manage garbage sustainably.
- It is necessary to digitalize systems, introduce new technologies into all port-related processes, and manage port services and operations sustainably.
- To increase the competitiveness of the transport and logistics chains, the environment for logistics and transportation has to be transformed based on automation and robotization.
- By collecting, analysing, and exchanging real-time data, intelligent infrastructure (including hardware and software) in ports may improve productivity and sustainability. According to the best practises currently in place for smart ports, the following intelligent infrastructures have been implemented in the ports: sensors, GPS/DGPS, RFID/OCR, GNSS, DGNSS, Bluetooth, WLAN, mobile devices, the Cloud, port community systems, port monitor system, port road management system, intelligent railway, smart maintenance, vessel traffic management, parking space management, and gate management.
- Ports may achieve continual improvement in their energy performance with the help of energy management systems.
- The use of a security management system will provide resilience in the face of risk and cost and loss optimisation. Ports must recognise their resources as well as potential external and internal risks, conduct risk analysis and risk management, and

improve staff readiness and knowledge. A current security management system must be continuously monitored and policies evaluated.

- For the improvement of Indian ports and terminals, the Indian government must invest more money in the implementation of cutting-edge technology and equipment. In a same manner, turnaround and dwell times may be shortened, and more ships can be handled, increasing national income.

- Encourage the sustainability of the environment through monitoring of greenhouse gas emissions and electrification- By switching from fuel to electricity-powered port equipment, the carbon footprint is reduced, especially if it is paired with environmentally friendly electricity sources like solar energy and renewable power generation technologies like solar, wind and ocean energy, or hydropower.

5.3 CONCLUSION

Rotterdam Port, Shanghai Port, JNPT, and Mundra Port are all significant ports that have unique features and advantages. While Rotterdam and Shanghai Ports are two of the busiest ports in the world, JNPT and Mundra Port are major ports in India that offer excellent connectivity to other ports in the region.

Rotterdam Port is located in the Netherlands and is one of the largest ports in Europe. It handles a wide range of cargo types, including oil, containers, and dry bulk. Rotterdam is known for its excellent infrastructure and efficient operations. The port is strategically located near major industrial and commercial centers in Europe, making it an ideal choice for businesses looking to export goods to the region. Rotterdam Port is also known for its environmentally sustainable practices, such as using renewable energy sources and reducing CO2 emissions.

Shanghai Port is located in China and is the busiest port in the world. It handles a massive volume of cargo, including containers, oil, and bulk cargo. Shanghai is known for its excellent connectivity to other ports in Asia and its efficient operations. The port is strategically located near major manufacturing centers in China, making it an ideal choice for businesses looking to export goods from China. Shanghai Port is also known for its modern

infrastructure and advanced technologies, such as automated container terminals and digital platforms for cargo tracking.

JNPT is located in Mumbai, India, and is the largest container port in India. It handles container traffic, including both import and export cargo. JNPT is known for its excellent connectivity to other ports in India and its strategic location near the industrial areas of Mumbai. The port has modern facilities, such as container terminals and warehouses, and offers services such as customs clearance and cargo tracking. JNPT is also known for its sustainable practices, such as using renewable energy sources and reducing waste.

Mundra Port is located in the state of Gujarat, India, and is one of the largest private ports in India. It handles a wide range of cargo types, including containers, bulk cargo, and liquid cargo. Mundra is known for its excellent infrastructure and efficient operations. The port has modern facilities, such as container terminals, warehouses, and tank farms, and offers services such as customs clearance and cargo tracking. Mundra is also known for its sustainability practices, such as using renewable energy sources and reducing emissions.

A smart port is an automated port that uses data analytics to make the best decisions for the company and efficiently manage operations. The idea is to leverage smart technology to boost a port's productivity, competitiveness, and efficiency. Automating procedures will assist the supply chain as a whole as well as the port.

A smart port is a port that is more efficient, productive, and economically competitive. Furthermore, Smart Ports see inhabitants as important stakeholders in their operations. They essentially deliver more with less by using real-time information, a collaborative management style, and these methods. A smart port is environmentally friendly, digital, and better connected to resources for sustainable development, business environments, and logistics. They are automated ports that prioritise the maritime environment while utilising innovative technology.

The maritime business of today is characterised by larger ships, a growing population, crowded ports, and the demand for speedier transportation of commodities due to the globalisation of the economy. Due to the predicted development of autonomous ships over the next ten years, being a smart digital port is now a need rather than a choice for ports that want to compete in the maritime sector. Making a port smarter entails making it more appealing since port competition is becoming more and more significant. Smart Ports reduce

congestion, which lowers pollution. Smart Ports adjust to automation, which improves connections between ports and stakeholders utilising automated ships or vehicles. Data improves system performance, resulting in time and money savings. Smart Ports employ intelligent data systems that are transparent and sustainable, have an open innovation mentality, and incorporate Big Data, Artificial Intelligence, Blockchain technology, non-stop services, efficiency, automation, and green technologies.

The study makes it quite evident that smart ports operate more effectively than conventional ports. The smart ports have higher yearly cargo tonnage, container volume handled, throughput, and income than regular ports (Indian Ports). Smart Ports feature the most cutting-edge and contemporary machinery. In smart ports, more ships can be handled, and dwell time and turnaround time are less than in conventional ports.

The Indian Ports can improve their policies with the help of Government of India and inviting private paSrticipation and the port authorities can raise the issue to increase financial powers. The competitiveness of Indian ports would also increase due to intra- and inter-port competition. Although the sites of the current main ports cannot be changed, it is strongly advised that Indian ports upgrade their infrastructures, reduce their expenses, and enhance their capacity in the future by investing more in them for greater performance and efficiency. The government and operators can work harder in the future to implement these aspects for the proposed ports.

In conclusion, the comparison of smart ports and Indian ports aims to provide insights into the potential benefits of implementing smart technologies in Indian ports. By understanding the differences and similarities between these ports, Indian ports can identify areas for improvement and adapt best practices from smart ports to enhance their performance. Additionally, the comparison can help to identify opportunities for collaboration and partnership between smart ports and Indian ports to drive innovation and growth in the maritime sector. Ultimately, the objective is to create a more efficient, sustainable, and competitive port ecosystem that benefits all stakeholders.

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