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A COMPREHENSIVE STUDY ON CONTAINER HANDLING PRACTICES AND TIME MANAGEMENT IN CHENNAI PORT AND ITS IMPACT DUE TO TRAFFIC

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Abstract: Efficient container cargo handling is critical to the seamless functioning of ports and the broader maritime logistics network. This study undertakes a focused examination of container handling practices and time management strategies at Chennai Port, aiming to identify operational inefficiencies that contribute to congestion, extended turnaround times, and logistical delays. Given the rising demand in international trade and containerized cargo movement, Chennai Port faces increasing pressure to handle volumes with greater speed and precision. The research evaluates key components such as terminal design, container movement patterns, equipment utilization, workforce deployment, and scheduling protocols. Special attention is given to traffic build up within and around the port, analysing how it impacts dwell times and overall efficiency. The study explores the integration of advanced solutions like automation, digital tools, and real-time data analytics to mitigate these challenges. It also underscores the importance of synchronized coordination among stakeholders, including shipping lines, terminal operators, and inland logistics providers. Comparative insights are drawn from global best practices, assessing their relevance and adaptability to the Indian context. Ultimately, the study proposes an optimized framework for container handling and traffic management at Chennai Port, aiming to improve service quality, enhance throughput, and strengthen the port's competitive standing in the global maritime sector.

Keywords: Container handling, Chennai Port, Time management, Port congestion, Turnaround time, Terminal operations, Maritime logistics, Traffic impact.

I. INTRODUCTION

In the rapidly transforming landscape of global maritime trade, the efficiency of container handling and effective time management have emerged as critical components in improving port performance and sustaining competitiveness. Chennai Port, one of India's major maritime gateways, plays a vital role in supporting international trade and regional economic activity. However, with the steady increase in containerized cargo traffic, the port is facing challenges such as congestion, extended dwell times, and delays in cargo movement, all of which impact the fluidity of operations.

This comprehensive study focuses on assessing container handling practices and time management strategies at Chennai Port, with particular attention to the impact of traffic within and around the terminal premises. By evaluating key operational aspects which includes equipment usage, workflow efficiency, intermodal coordination, and vessel turnaround times, the research aims to uncover critical bottlenecks and propose actionable improvements.

Need for study:

This study focused on India's 13 major ports are critical to the country's trade and economic growth, yet disparities in operational performance, cargo handling efficiency, turnaround times, and revenue generation highlight the need for a comprehensive evaluation. This study is necessary to identify and compare inefficiencies across these ports, analyze infrastructure capabilities and connectivity, and assess their impact on overall performance. By using statistical techniques to evaluate key indicators, the study aims to uncover performance gaps, provide data-driven insights, and propose strategic interventions to streamline operations, enhance efficiency, and support policy decisions for modernizing the Indian port sector and improving its global competitiveness.

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Scope of the Study:

This study is cantered on evaluating container handling operations at Chennai Port, with the objective of identifying inefficiencies and enhancing time management in cargo movement. The research covers critical areas such as terminal layout, container flow, equipment utilization, and scheduling systems, aiming to improve the overall efficiency of port operations. Analysing container handling practices at Chennai Port, focusing on vessel turnaround time, loading/unloading performance, and yard management.

Objectives:

To analyse and evaluate the impact of container traffic congestion at Chennai Port and assess the container handling efficiency and time management, To analyse monthly and yearly trends in cargo volumes, TEUs, and vessel movement, highlighting growth patterns, delays, and productivity across ports, To identify and assess operational inefficiencies in container handling and vessel turnaround at Major Indian ports, To examine the performance metrics (Average Turnaround Time, pre-berthing time, idle time, and berth output) to evaluate time management and equipment utilization.

II. LITERATURE REVIEW

1) LinGu, Honghao Xu, Ziyuan Li,Zirui Chen & HaiJin, (2023)-*"Container Session Level Traffic Prediction from Network Interface Usage."*

Provisioning cloud native services via containers has been regarded as a promising way to promote the cloud elasticity. A container may simultaneously sustain multiple services with a number of different communication sessions. It is of great importance to predict them for fine-grain system management. However, this is a non-trivial task as the session traffics are all invisible. The only thing we can get is the container network interface usage as the total traffic of all coexisting sessions. In this paper, we propose a machine learning based session level traffic prediction framework called X-Rayer, to predict respective session traffics from the network interface usage. Via a sliding-window based ensemble empirical mode decomposition algorithm, X-Rayer first accurately predicts the interface usage, which is then decomposed into session traffics by an invented ConvGRU formed by convolutional neural network and gated recurrent unit. Specially, the spatial-temporal correlations of the interface usages are abstracted via an attention strategy and explored for accurate session traffic decomposition

2) Hongxiang Feng, Manel Grifoll, Pengjun Zheng, Martin, Frank Murphy and Song Li. (2021)-*"Evolution and container traffic prediction of Yangtze River Delta multi-port system (2001-2017. "*

This contribution investigates the latest concentration tendency of Yangtze River Delta (YRD) multi-port system with concentration-ratio, Herfindahl-Hirschman-Index and shift-share-analysis. Results show that Zhejiang is the major winner; Shanghai is losing its oligopoly since 2012; Shanghai, Zhejiang and Jiangsu are reaching tripartite equilibrium. Then, ARIMA, linear regression and GM (1, 1) are used to forecast container throughput of Shanghai, Zhejiang, Jiangsu and YRD. By mean absolute percent error (MAPE), all models have good or reasonable performance, ARIMA performs best with MAPE of 2.37%, 2.41% and 6.54% when time series seem linear, however does not has excellent performance (MAPE is 14.26%) when non-linear. Finally, we use the indirect and direct method to forecast; MAPE decreases to 3.85% using ARIMA, which supports the out-performance of indirect forecast. The combination of concentration index analysis and forecasting methods has allowed to gain insight in the evolution and prospects of YRD container multi-port system.

3) Grubišić, Krljan & Sesar.(2023)-*"Traffic Microsimulation of the Main Junction Connecting the Urban Road Network with the Sea-Port Container Terminal."*

Efficient transportation connectivity between ports and the hinterland is essential for the functioning of the port, especially for container terminals that predominantly rely on road transport. The integration of port and urban traffic flows, particularly in terminals located near cities, has a double impact on the level of service of urban traffic and the efficiency of the port. This paper examines the effects of a newly built container terminal, with a capacity of less than 1 million TEU per year, on urban traffic in Rijeka, Croatia. A microscopic-level simulation method is used together with traffic network modeling design. The research identifies potential bottlenecks or critical elements in the network with lower performance for the current traffic demand and the future growth scenarios of the container traffic. The study's findings contribute to understanding the dynamic characteristics of port and urban traffic flow correlation, crucial for efficient transportation management and sustainable urban development in port cities.

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4) Hsien-Pin Hsu, Chia-Nan Wang, Hsin-Pin Fu &Thanh-Tuan Dang. (2021)- ***"Joint Scheduling of Yard Crane, Yard Truck, and Quay Crane for Container Terminal Considering Vessel Stowage Plan: An Integrated Simulation-Based Optimization Approach."***

(QCs), yard cranes (YCs), and yard trucks (YTs) is critical to achieving good overall performance for a container terminal. However, there are only a few such integrated studies. Especially, those who have taken the vessel stowage plan (VSP) into consideration are very rare. Neglecting this plan will cause problems when loading/unloading containers into/from a ship or even congest the YT and YC operations in the upstream. In this research, a framework of simulation-based optimization methods has been proposed firstly. Then, four kinds of heuristics/metaheuristics has been employed in this framework, such as sort-by-bay (SBB), genetic algorithm (GA), particle swarm optimization (PSO), and multiple groups particle swarm optimization (MGPSO), to deal with the yard crane scheduling problem (YCSP). The objective aims to minimize makespan. Each of the simulation-based optimization methods includes three components, load-balancing heuristic, sequencing method, and simulation model. Experiments have been conducted to investigate the effectiveness of different simulation-based optimization methods. The results show that the MGPSO outperforms the others.

5)Marco Caserta, Silvia Schwarze & Stefan, (2020).-" ***Container rehandling at maritime container terminals: A literature update."***

This chapter provides an updated survey on rehandling of containers at maritime container terminals. In particular, we review contributions with a particular focus on post-stacking situations, i.e., problems arising after the stacking area has already been arranged. Three types of post-stacking problems have been identified, namely (1) the re-marshalling problem, (2) the pre-marshalling problem, and (3) the relocation problem. This research area has received an increasing attention since the first version of this contribution appeared in 2011. Within this update, we discuss recent developments presented in literature. Available solution approaches from the fields of exact and (meta-)heuristic methods are given and benchmark datasets are summarized. Moreover, an overview on extensions of post-stacking problems and according to solution methods are discussed.

6) Minsu Kim, Yoonjea Jeong & Ilkyeong Moon. (2021).-*"Efficient stowage plan with loading and unloading operations for shipping liners using foldable containers and shift cost-sharing."*

In this paper, we investigate the foldable container slot planning problem with loading and unloading operations that include shifting containers in a shipping line. We use the global optimal perspective in which a terminal operator generates an optimal stowage plan created based on demand at subsequent ports. State-of-the-art foldable containers have been recently used in commercial maritime transport systems because they confer space-saving advantages when folded. We investigate container use through mixed-integer programming and shift cost-sharing methods as means to prevent conflicts between ports over inessential shifts and to provide guidelines for distributing shift costs among all ports in a logical and fair way. Through the proposed model, we found that most inessential shifts, considered inevitable from the local optimal perspective, can be eliminated, and the inevitable shift costs can be distributed.

III. RESEARCH METHODOLOGY

The arrangement of gathering information for research ventures is known as research system. The information might be gathered for either hypothetical or down to earth look into for instance the board research might be deliberately conceptualized alongside operational arranging strategies and change Management.

METHOD OF DATA COLLECTION

Primary Data: Primary data refers to original data collected first-hand by researchers specifically for their research purposes. Primary data was gathered through various methods such as surveys, interviews, observations, and experiments. Surveys and informal discussions with operational personnel and cargo handling planners at SCI were conducted to gather practical insights into current handling techniques, software tools used, and bottlenecks affecting efficiency and time management.

Secondary Data: Secondary data sources could include existing information such as published reports, industry statistics, and internal company data. The secondary data was collected through existing sources like websites, articles, Books, company websites, Google, Magazines, journals, Newsletters.

RESEARCH DESIGN

Research design is the specification of the method and procedure for acquiring the information needed to solve the problem by following statistical tools.

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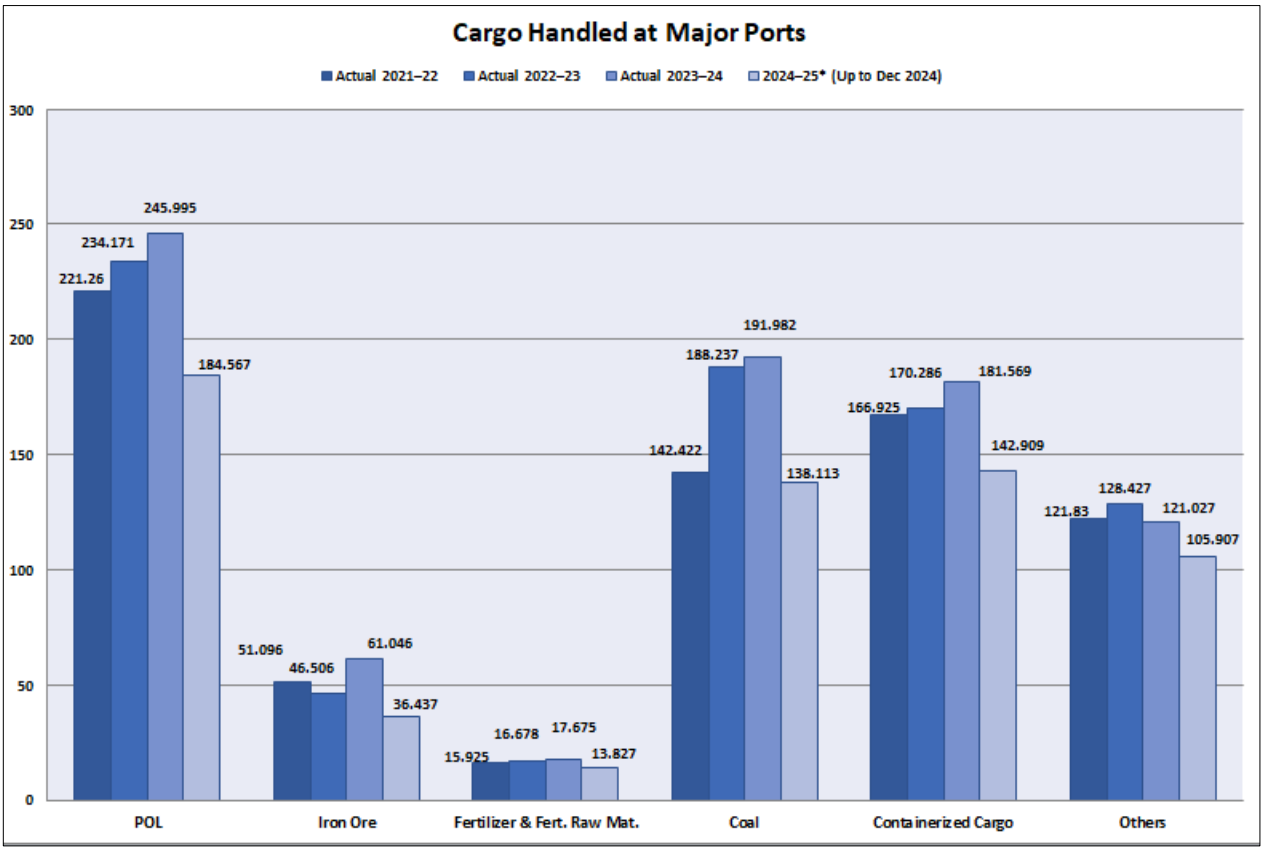
DATA ANALYSIS TOOL: Data analysis is a critical component in the research design process, providing the means to interpret and draw meaningful conclusions from collected data. It involves the systematic examination of data to identify patterns, relationships, and trends that can address the research objectives. Various statistical and analytical techniques are employed to organize, summarize, and interpret the data, ensuring its reliability and validity. The choice of analytical methods depends on the nature of the data and the research questions being addressed. Proper data analysis not only validates the research findings but also enhances the overall credibility and quality of the research study.

POWER BI / TABLEAU: Visualization tools are essential for transforming raw data into meaningful insights. In the context of logistics and supply chain management, they help to understand complex patterns, trends, and relationships that would be difficult to discern from spreadsheets or tables alone. By selecting and effectively using appropriate visualization tools, Fast Logistics can gain valuable insights from its data, improve decision-making, and optimize its operations.

ANALYSIS & INTERPRETATION

Cargo Handled at Major Ports

Commodity	Actual 2021–22	Actual 2022–23	Actual 2023–24	2024–25* (Up to Dec 2024)
POL	221.266	234.171	245.995	184.567
Iron Ore	51.096	46.506	61.046	36.437
Fertilizer & Raw Fertilizer.	15.925	16.678	17.675	13.827
Coal	142.422	188.237	191.982	138.113
Containerized Cargo	166.925	170.286	181.569	142.909
Others	121.83	128.427	121.027	105.907
Total	719.464	784.305	819.294	621.76



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The chart presents a comparative analysis of cargo handled by major Indian ports across four consecutive fiscal years: 2021–22, 2022–23, 2023–24, and 2024–25 (up to Dec 2024). A general upward trend is noticeable in certain cargo categories, while others exhibit stagnation or decline.

Among the standout categories, POL (Petroleum, Oil & Lubricants) handled the highest volume of cargo throughout all four years, with a consistent rise from 221.26 MT in 2021–22 to 245.995 MT in 2023–24, followed by a dip to 184.567 MT in 2024–25 indicating a potential seasonal or partial-year effect rather than an annual decline. Similarly, Coal recorded a steady increase from 142.422 MT in 2021–22 to 191.982 MT in 2023–24, showing strong and growing demand in this segment; although a partial dip to 138.113 MT is seen in the 2024–25 data.

Containerized Cargo also showed consistent improvement from 166.925 MT in 2021–22 to 181.569 MT in 2023–24, underlining a strengthening role of container traffic in India's cargo profile, though the partial data for 2024–25 (142.909 MT) suggests continued growth if trends remain stable. Iron Ore saw gradual improvement each year, rising from 46.506 MT in 2022–23 to 61.046 MT in 2023–24, pointing to renewed activity in bulk exports or industrial usage. Conversely, Fertilizer and Fertilizer Raw Materials showed modest growth but at low volumes, moving from 15.925 MT in 2021–22 to 17.675 MT in 2023–24, with a slight drop to 13.827 MT in 2024–25 so far. Others, a category capturing mixed cargo types, showed fluctuations, peaking at 128.427 MT in 2022–23 but dropping to 105.907 MT in 2024–25 (up to Dec), suggesting variable throughput.

KEY OBSERVATIONS: POL continues to dominate cargo volumes with strong growth up to 2023–24, while Coal and Containerized Cargo also show steady increases, reflecting both infrastructure readiness and rising demand. Iron Ore has demonstrated recovery and upward momentum in recent years, whereas Fertilizer and Other cargo categories show mixed or stagnating trends. This suggests the need for strategic planning and diversification to boost growth in underperforming segments as infrastructure and trade patterns evolve.

PORT PERFORMANCE DATA OF INDIAN MAJOR PORT
Traffic Handled in Million Metric Tons at Major Ports

Port	Actual 2021–22	Actual 2022–23	Actual 2023–24	2024–25* (Up to Dec 2024)
Kolkata	15.296	17.052	16.909	11.276
Haldia	42.877	48.608	49.536	32.923
Paradip	116.133	135.362	145.379	109.517
Visakhapatnam	69.03	73.75	81.09	60.476
Chennai	48.654	48.949	51.598	40.602
V.O. Chidambaranar	35.822	38.041	41.402	30.621
Cochin	34.55	35.255	36.315	26.256
New Mangalore	39.116	41.417	45.707	33.309
Mormugao	18.496	17.334	26.17	18.523
Jawaharlal Nehru	75.996	71.843	85.818	61.473
Mumbai	63.058	63.808	67.271	50.305
Deendayal (Kandla)	127.1	137.561	132.374	103.383
Kamarajar (Ennore)	36.172	43.507	45.277	33.092

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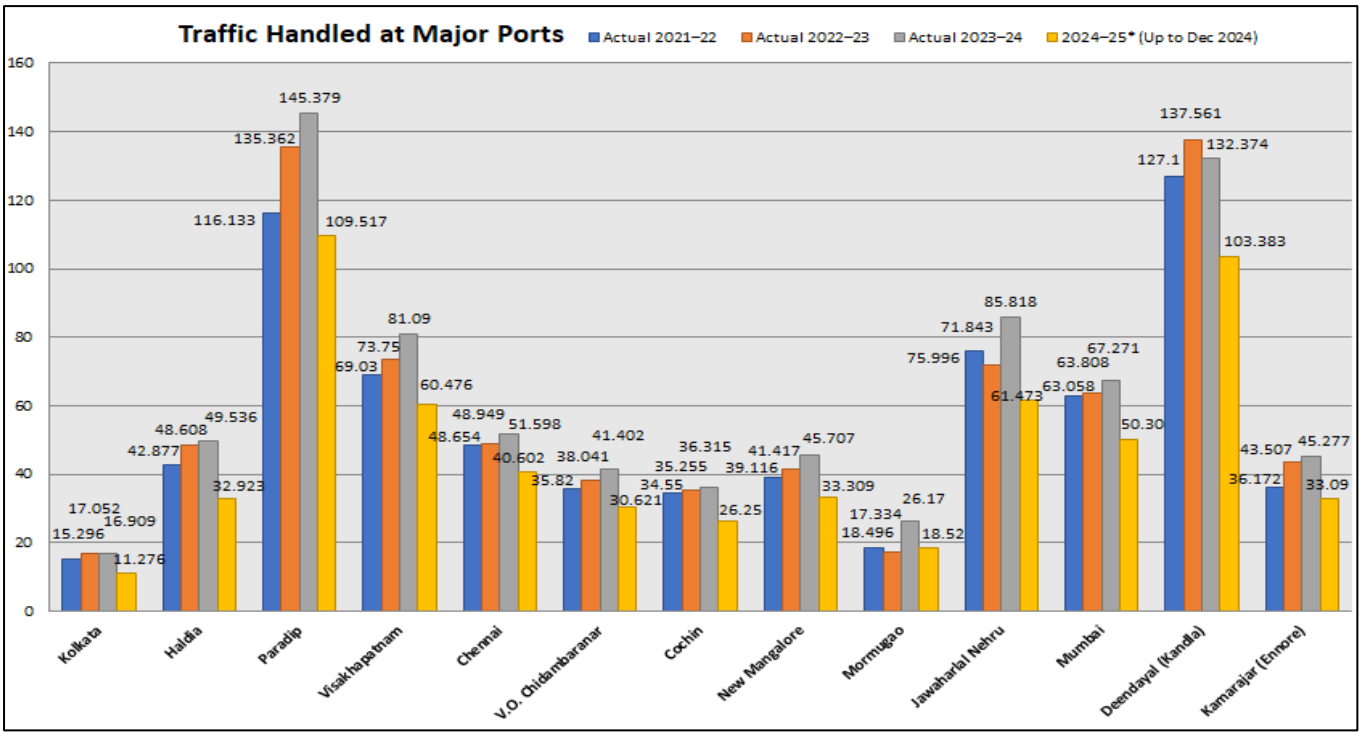
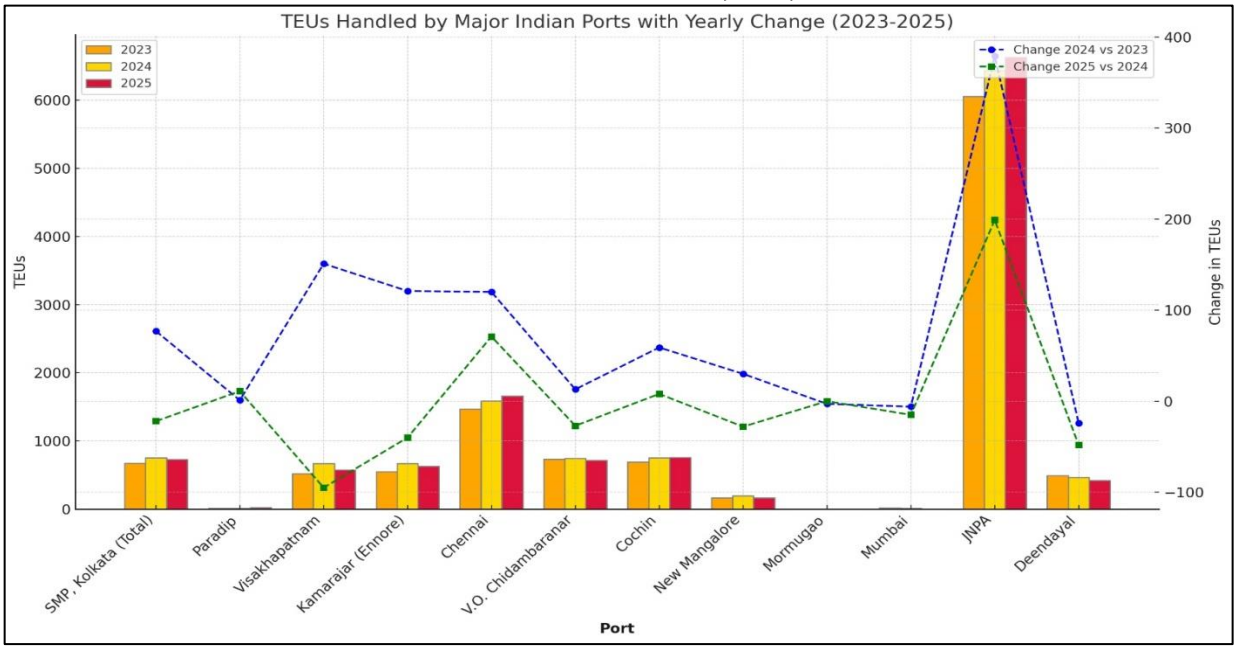


The bar chart compares traffic handled at major Indian ports from 2021–22 to 2024–25 (up to December), showing key trends in port performance. Paradip Port leads with consistent growth, followed by Deendayal Port, which showed strong performance despite a dip in 2024–25, likely due to partial data. Ports like Visakhapatnam and JNPT show steady increases, reflecting improved cargo efficiency. Chennai, V.O. Chidambaranar, Cochin, Kamarajar, and New Mangalore also recorded moderate but stable growth. In contrast, Mumbai, Kolkata, and Mormugao showed stagnation or decline, indicating operational challenges or reduced cargo movement.

Key observations: Paradip and Deendayal remain dominant in bulk cargo handling. Eastern ports (Visakhapatnam, Paradip) are showing accelerated growth, Some ports, like Kolkata and Mormugao, continue to handle lower volumes and may need modernization or strategic reorientation.

A COMPARATIVE ANALYSIS OF TEUs HANDLED BY MAJOR INDIAN PORTS ACROSS THREE CONSECUTIVE YEARS: 2023, 2024, AND 2025



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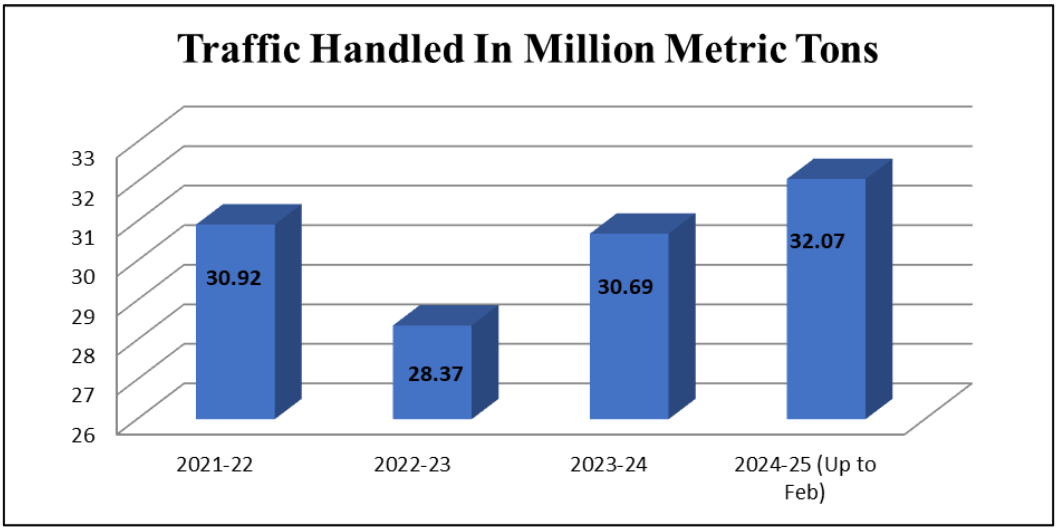
The chart compares total TEUs handled by major Indian ports from 2023 to 2025, revealing overall growth in container traffic, particularly at JNPA, Chennai, and V.O. Chidambaranar ports. JNPA led in volume, peaking in 2024 before slightly stabilizing, while Chennai and V.O. Chidambaranar showed consistent year-on-year increases. In contrast, ports like Deendayal and Visakhapatnam experienced declines, highlighting operational or demand challenges. The analysis underscores regional performance disparities and suggests a need for infrastructure upgrades and strategic diversification to boost capacity at underperforming ports.

PORT PERFORMANCE DATA OF CHENNAI PORT OVER FOUR FISCAL YEARS FROM 2021–22 TO 2024–25 (UP TO FEBRUARY)

TRAFFIC HANDLED IN MILLION METRIC TONS AT CHENNAI PORT

Year	Traffic Handled In MMT
2021-22	30.92
2022-23	28.37
2023-24	30.69
2024-25 (Up to Feb)	32.07



4.1.17 TOTAL NUMBER OF VESSELS HANDLED AT CHENNAI PORT

Year	No. of Vessels Handled
2021-22	700
2022-23	698
2023-24	756
2024-25 (Up to Feb)	752

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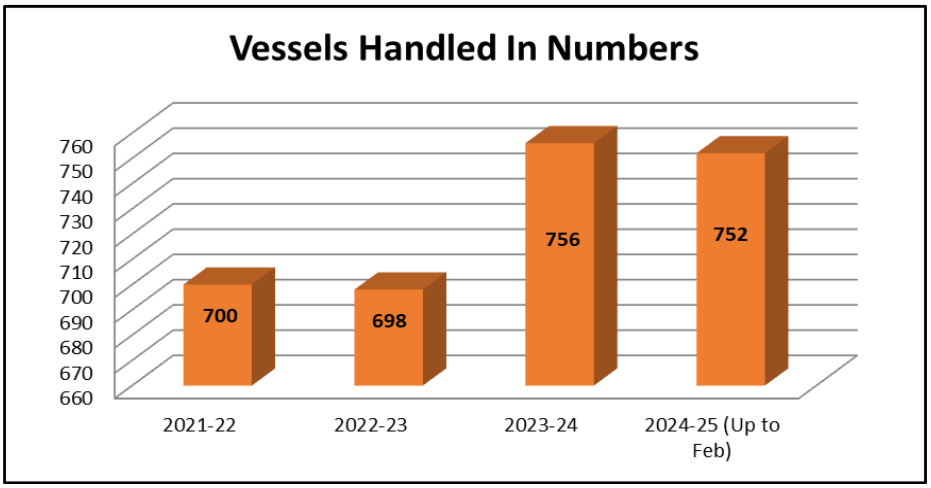
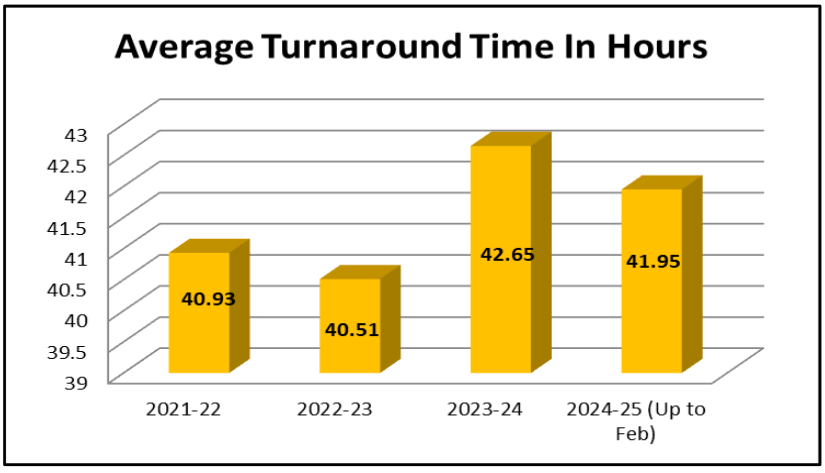


THE AVERAGE TURNAROUND TIME (IN HOURS) FOR VESSELS AT CHENNAI PORT

Year	Average Turnaround Time -In Hours
2021-22	40.93
2022-23	40.51
2023-24	42.65
2024-25 (Up to Feb)	41.95



KEY OBSERVATIONS ON PORT PERFORMANCE DATA

The port has demonstrated resilience with steady cargo traffic growth since 2022–23, with 2024–25 (up to February) already surpassing previous full-year volumes. Vessel calls have risen significantly, accompanied by improved vessel handling performance and higher port utilization. While berth productivity has recovered from the 2022–23 dip, idle time remains over 18%, signaling the need for better resource management. Pre-berthing time dropped sharply in 2023–24 but spiked again in 2024–25, indicating possible congestion or planning issues. Turnaround time showed an uneven trend, rising in 2023–24 and slightly declining in 2024–25. Although average ship berthing output has improved marginally, overall performance reflects positive momentum with clear opportunities to enhance efficiency through better planning and digitalization of berth and cargo operations.

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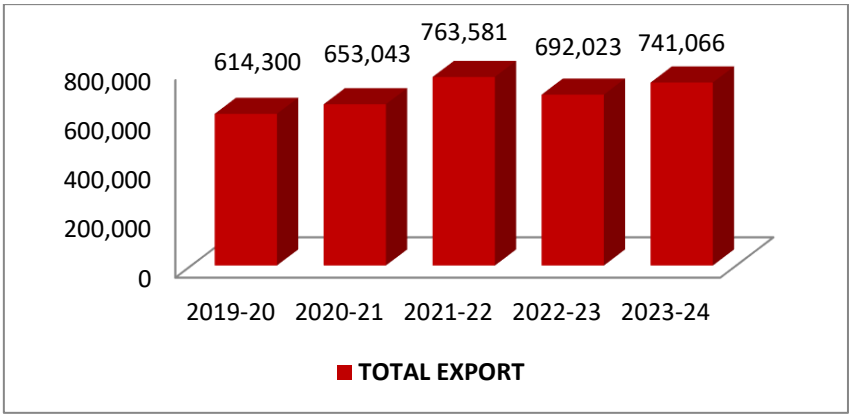
TOTAL NUMBER OF TEU'S EXPORTED THROUGH CHENNAI PORT

Year	TOTAL EXPORT
2019-20	6,14,300
2020-21	6,53,043
2021-22	7,63,581
2022-23	6,92,023
2023-24	7,41,066



TOTAL EXPORTS FROM 2019–20 TO 2023–24 – DATA INTERPRETATION

Total exports over the period amounted to consistent growth, starting from ₹6,14,300 in 2019–20 and reaching ₹7,41,066 in 2023–24. The highest export figure was recorded in 2021–22 at ₹7,63,581, demonstrating a strong peak in the trend. Although there was a dip in 2022–23 to ₹6,92,023, the sector rebounded in 2023–24, showing resilience and recovery. From 2019–20 to 2020–21, exports increased modestly from ₹6,14,300 to ₹6,53,043, maintaining a steady growth rate. The substantial jump between 2020–21 and 2021–22 reflects a period of significant export expansion. The dip in 2022–23 may suggest temporary challenges, such as global trade disruptions or domestic production issues. However, the recovery in 2023–24 almost matched the previous peak, indicating strong corrective measures and market demand. The cumulative trend over five years indicates a general strengthening of the export sector, despite short-term fluctuations.

KEY OBSERVATIONS: Exports exhibited steady growth over the five-year period, with only a minor decline in 2022–23 following the peak performance in 2021–22, likely due to favourable economic conditions that year. The dip highlights the impact of external challenges, but the recovery in 2023–24 reflects sectoral resilience. Overall, the export sector is on a positive trajectory, and with strategic efforts to sustain and build on this recovery, future export levels have strong potential to surpass the 2021–22 peak.

TOTAL NUMBER OF TEU'S IMPORTED EXPORTED CHENNAI PORT

Year	TOTAL IMPORT
2019-20	7,69,671
2020-21	7,33,883
2021-22	8,38,738
2022-23	7,78,282
2023-24	8,48,474

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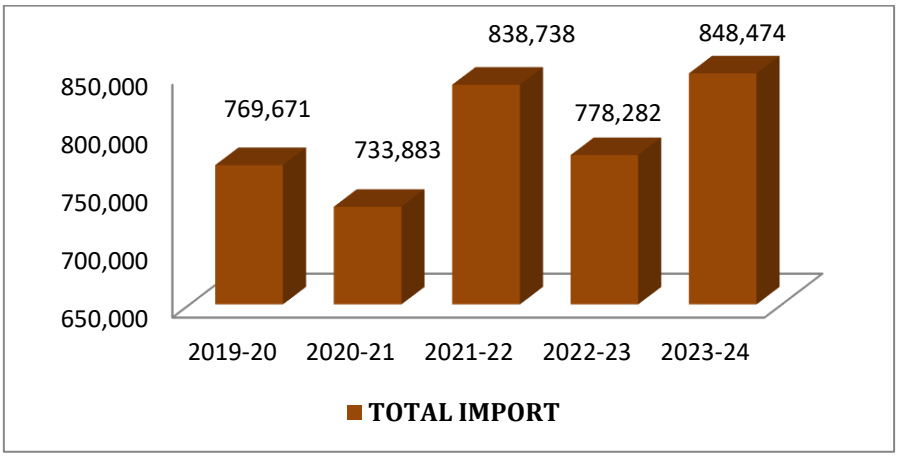

TOTAL IMPORTS FROM 2019–20 TO 2023–24 – DATA INTERPRETATION

Total imports over the period showed fluctuating trends, starting at ₹7,69,671 in 2019–20 and increasing to ₹8,48,474 in 2023–24. Imports slightly decreased from ₹7,69,671 in 2019–20 to ₹7,33,883 in 2020–21, reflecting a temporary slowdown. However, a significant rise was seen in 2021–22, with imports reaching ₹8,38,738 — the second-highest figure during the five-year period.

In 2022–23, imports declined to ₹7, 78,282, likely influenced by global market conditions, supply chain issues, or regulatory factors. Nevertheless, 2023–24 recorded the highest imports at ₹8,48,474, demonstrating robust growth and recovery beyond previous peaks. The overall trend suggests resilience in import activities despite mid-term fluctuations, with the latest figures indicating strong domestic demand and economic momentum.

KEY OBSERVATIONS: Imports fluctuated over the five-year period, with the lowest value recorded in 2020–21 likely due to pandemic-related disruptions, but ended on a strong upward trend, culminating in a record high in 2023–24 that surpassed the previous peak of 2021–22. This recovery suggests strengthening economic activity and rising domestic consumption. The data points to opportunities for sustaining elevated import levels while simultaneously focusing on enhancing complementary export capacities to maintain trade balance.

FINDINGS

Petroleum, Oil & Lubricants (POL) and Coal remain the top commodities handled at major Indian ports, showing consistent growth (except for partial-year dips in 2024–25).
Containerized cargo has steadily increased, indicating rising trade efficiency and demand for container-based logistics.
Iron ore shipments rebounded in 2023–24 (61.046 MT), suggesting renewed industrial demand or export opportunities.
Fertilizer and miscellaneous cargo categories show stagnation, highlighting potential inefficiencies or lower demand.
Paradip and Deendayal ports handle the highest cargo volumes, driven by bulk commodities like coal and POL.
JNPT leads in TEU handling, but a slight dip in 2025 suggests operational or demand-side challenges.
While cargo traffic and vessel handling improved, pre-berthing delays and idle time (~18%) remain concerns.
Despite a dip in 2022–23, TEU exports/imports rebounded in 2023–24, reflecting strong trade recovery.
Chennai Port's pre-berthing time spiked in 2024–25 (0.9 hours), indicating congestion or planning gaps.
Visakhapatnam and Paradip show robust growth, while western ports like Mumbai and Mormugao lag.

SUGGESTIONS:

The Indian government is implementing several strategies to improve port infrastructure, operational efficiency, and sustainability. These include upgrading port infrastructure, adopting advanced technologies like AI and IoT, improving road, rail, and multimodal connectivity, adopting best practices in vessel and cargo handling, implementing environmental management systems, strengthening inland connectivity, reforming port governance, implementing digital platforms, developing new terminals, and enhancing multimodal connectivity. The Sagarmala Project aims to enhance port connectivity, port-led industrialization, and coastal community development, unlocking India's coastline and waterways' potential, stimulate economic growth, and make the maritime sector globally competitive and sustainable.

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IV. CONCLUSION

In conclusion, to remain competitive in the global maritime industry, close collaboration with Chennai Port is essential to modernize container handling, adopt digital tools, and implement time-efficient practices. Investments in mechanization, real-time scheduling, and improved connectivity are crucial to reducing congestion, enhancing turnaround times, and ensuring reliable, sustainable operations.

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