



## Enhancing Efficiency through Multi-Modal Logistics and Port Automation: A Case Study of Paradip Port

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DOI : <https://doi.org/10.55248/gengpi.5.1024.3002>

### ABSTRACT

This case study examines how Paradip Port successfully implemented a multi-modal logistics and port automation project, which resulted in a notable improvement in operational efficiency. One of the main ports in India, Paradip Port was having problems with traffic, sluggish cargo handling and ineffective logistics, which led to delays and increased operating expenses.

Paradip Port, a key maritime hub in India, is pivotal in supporting international trade by offering seamless connectivity between maritime and inland transport modes. The study analyses the integration of road, rail, and sea transport, highlighting the benefits of a coordinated logistics network that reduces transit times, minimizes handling costs, and optimizes cargo movement.

Key areas of focus include the port's infrastructure development, advanced digital tracking systems, and the deployment of automated solutions to ensure faster cargo clearance. The research also explores the port's initiatives to adopt sustainable practices and reduce carbon emissions, which contribute to overall cost savings and environmental impact mitigation. The port authorities employed cutting-edge automation technologies in port operations and created a multi-modal logistics system that integrated road, rail, and sea traffic to overcome these problems. To optimize cargo flow, the project included automating container handling, utilizing real-time tracking technologies, and improving communication amongst transport modes.

The findings suggest that the multimodal logistics approach not only increased Paradip Port's competitiveness but also supports India's broader economic goals by enabling smoother trade flows, reducing bottlenecks, and improving stakeholder collaboration across the supply chain.

The study concludes with recommendations for further improvements in intermodal connectivity, investment in technology, and policy measures to enhance operational efficiency at the port, ensuring its position as a leader in global maritime logistics.

**Keywords:** - Port-Automation, Multi-Modal logistics, Operational Efficiency, Cargo Handling, Supply Chain Optimization, Transport Integration

### INTRODUCTION

The effectiveness of logistics and transportation networks is essential in today's globalized economy to preserving a competitive advantage in trade and commerce. Ports are essential to the supply chain since they are the hub of global trade. One of India's main seaports, Paradip Port, has grown to be an important bulk cargo hub, specializing in coal, iron ore, and other industrial raw materials. But as supply chain demands changed and global trade volumes rose, the port had to deal with a number of operational difficulties that made it harder for it to keep up with the expanding expectations of companies.

In the past, Paradip Port has encountered obstacles in the transportation and management of cargo, which has led to extended ship turnaround times, increased operational expenses, and ineffective utilization of available resources. Some of the major problems impeding the port's performance were congestion, a lack of coordination between the various modes of transportation (road, rail, and sea), and delays in the processing of shipments. In order to improve operating efficiency and reduce delays, Paradip Port had to update and implement cutting-edge technologies due to rising trade pressure.

The Paradip Port authorities undertook a revolutionary journey to address these difficulties by implementing a comprehensive multi-modal logistics and port automation project. The goal of this project was to combine land, rail, and sea transportation into a unified system that could more effectively control the flow of freight. Simplifying the flow of commodities from the port to the hinterland and vice versa was the aim in order to improve supply chain performance overall and minimize bottlenecks.

The use of cutting-edge automation technologies was a crucial part of this modernization endeavour. The port implemented automated systems for handling containers, provided real-time cargo tracking, and improved communication networks among various transport nodes. By applying automation to document processing, storage management, and loading and unloading procedures, the reliance on manual labor was greatly reduced, and the possibility of human error was reduced. This resulted in faster operations as well as more dependable and regular service.

In addition, the implementation of a multi-modal logistics system facilitated the smooth transfer of cargo across land, air, and sea, maximizing routes for transit and cutting down on transit times. The smooth integration of various forms of transportation allowed for more effective handling of cargo, guaranteeing the timely and economical transportation of commodities. By taking a comprehensive strategy, the port's congestion was lessened, and the movement of commodities to and from the nation's industrial areas was enhanced.

These initiatives significantly increased Paradip Port's operational efficiency. Ship turnaround times were shortened, cargo processing speeds enhanced, and the port's overall throughput capacity expanded. In addition, the port and its customers benefited financially greatly from the cost savings brought forth by automation and improved logistics.

In conclusion, the Paradip Port multi-modal logistics and port automation project is an effective example of process optimization and technology integration in a marine environment. Paradip Port has established a standard for other Indian ports aiming to improve their productivity and better satisfy the demands of international trade by modernizing its operations. This case study provides insightful information for port managers and logistics experts alike by examining the tactics employed, the obstacles faced, and the outcomes attained.

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## LITERATURE REVIEW

**Le, D. N., Nguyen, H. T., & Truong, P. H. (2020)** have found out that responsiveness, certainty, reliability, tangibles, and empathy are the five criteria that positively influence the quality of port logistics services.

**Theo Notteboom and Jean-Paul Rodrigue (2008)** have opined that in a market where freight transportation has emerged as the most unpredictable and expensive element of many businesses' supply chains and logistics operations, the container system is gradually maturing.

**Kevin Cullinane & Rickard Bergqvist (2014)** have stated that fuel usage and emissions in the marine sector are closely related. But once more, because shipping is an international industry, it might be challenging to even calculate the total amount of fuel used. Historically, top-down assessments of fuel sales data from bunker providers have been used to generate estimates.

**Southworth, F., & Peterson, B. E. (2000)** focused and studied that various mixes of truck, rail, and water transportation are used in routings. The utilization of geographic information systems (GIS) technology proved to be extremely beneficial in the economical building and upkeep of this network, as well as in the following verification of route choices and mode sequences. It was discovered that the most effective way to route intermodal freight shipments computationally was not within a geographic information system (GIS).

**Rondinelli, D., & Berry, M. (2000)** concluded that demand to proactively manage the environmental impacts of transportation systems will grow as multimodal transportation facilities and intermodal logistics services become more in demand, and as seamless transportation plays a more crucial role in integrated logistics and effective supply chain management in the twenty-first century.

**Romagnoli S. Tarabu' C. Maleki Vishkaei B. De Giovanni P. (2023)** have investigated how companies may improve the performance of their circular supply chains (CSCs) by implementing a range of sustainable practices and digital technology. To enhance the influence of technologies and sustainable practices on CSCs and further improve performance, it examines the advantages that businesses can reap from investing in particular technologies.

**Caris, A., Limbourg, S., Macharis, C., van Lier, T., & Cools, M. (2014)** have identified the opportunities that will allow for the increased integration of inland waterway transport in the intermodal supply chain are identified in this study. One way to think of intermodal transport is as a network of providers of transportation services. A key factor in improving supply chain service performance is inland navigation.

**SteadieSeifi, M. (2014)** has inferred in her research that a sophisticated platform for freight transportation that is more effective, dependable, adaptable, and sustainable is provided by multimodal transportation.

**Levinson, M. (2006)**, author of the book *The Box* narrates the dramatic tale of the container's invention, the ten years of resistance before it was extensively used, and the far-reaching economic effects of containerization's precipitous decrease in transportation costs.

**Sarkar, B.D., Shankar, R. and Kar, A.K. (2023)** have studied the issues with loading and unloading, transit, storage (warehouse), customs clearance, regulatory bodies, port management units, and providers of inland transport connections. They have also identified the main problems, numerous inefficiencies, and underlying causes that different port logistics actors deal with when exchanging information, moving cargo, scheduling cargo shipments, etc.

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## PERFORMANCE OF THE PARADIP PORT

### OPERATIONAL PERFORMANCE

A quantity of 1353.62 lakh tonnes of total traffic handled at this port during the year 2022-23 as compared to 116.33 lakh tonnes in 2021-22 and 1145.49 lakh tonnes in 2020-21. The principal commodity wise traffic during the year and variations as compared to previous year shown below.

Commodity	2022-23	2021-23	% of variation
Thermal coal	490.90	309.70	58.51
Coking coal	134.33	137.42	-2.25
FRM(Dry)	49.54	48.02	3.17
POL	378.40	351.26	7.73
Container Cargo	1.92	1.85	3.78
Fertilizer	5.53	3.89	42.16
Iron Ore	103.20	97.57	5.77
Others	189.80	211.62	-10.31
<b>Total</b>	<b>1353.62</b>	<b>1161.33</b>	<b>16.56</b>

The year-wise traffic handled during the last 5 years are given below:

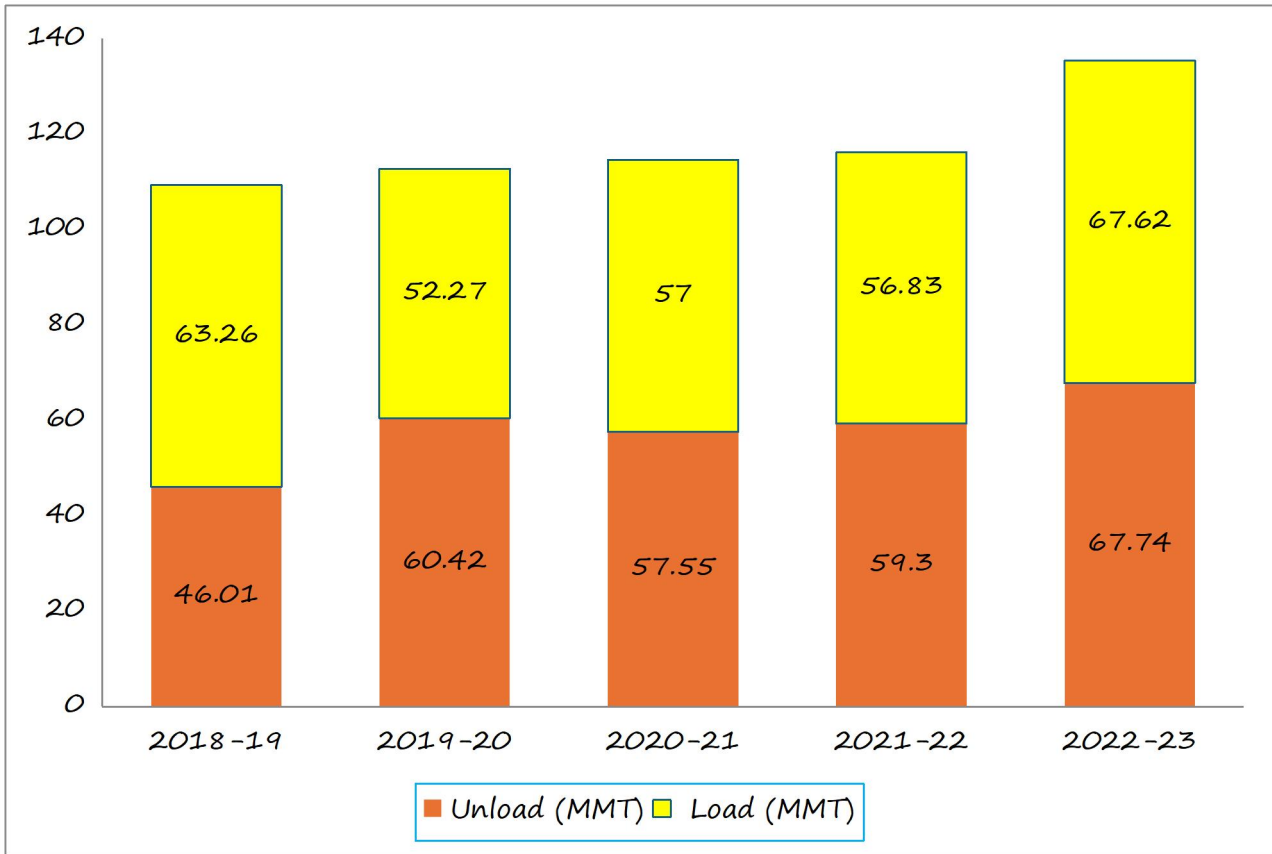
(Figures in lakh tonnes)

Year	Load	Unload	Container cargo		Transshipment	Total
2018-19	458.53	632.28	1.58	0.36	0	1092.75
2019-20	521.34	603.33	1.32	0.9	0	1126.89
2020-21	568.13	574.57	1.84	0.95	-	1145.49
2021-22	567.09	592.39	1.21	0.64	-	1161.33
2022-23	674.54	674.54	1.37	0.56	0.33	1353.62

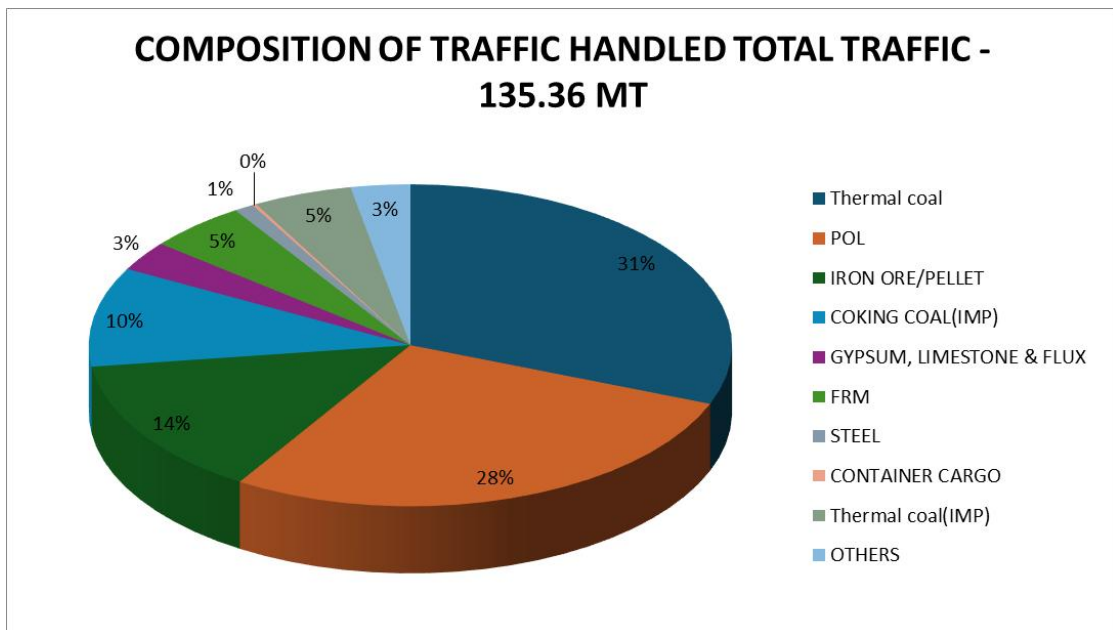
The break-up of foreign and coastal traffic for unload and load cargoes during last 5 years are given below: -

Year	UNLOADED			LOAD		
	Foreign	Coastal	Total	Foreign	Coastal	Total
2018-19	620.31	12.33	632.64	89.83	370.28	460.11
2019-20	593.21	11.02	604.23	179.59	343.07	522.66
2020-21	559.5	16.01	575.51	278.53	291.44	569.97
2021-22	575.32	17.71	593.03	163.98	404.32	568.3
2022-23	654.57	22.81	677.38	114.49	561.43	675.92

TRAFFIC HANDLED DURING LAST 5 YEARS

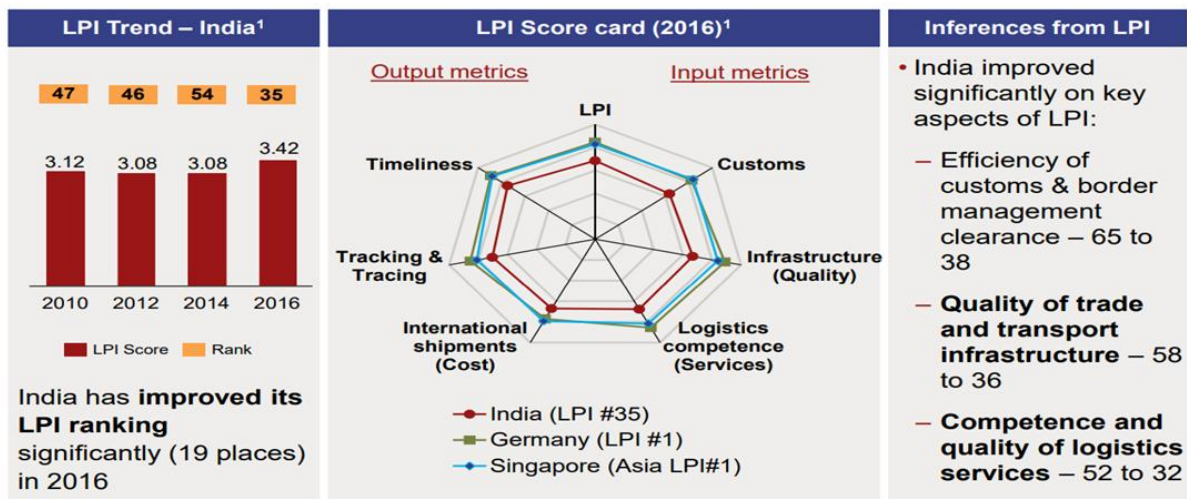


	2018-19	2019-20	2020-21	2021-22	2022-23
Unload (MMT)	63.26	60.42	57.55	59.30	67.74
Load (MMT)	46.01	52.27	57.00	56.83	67.62
TOTAL(MMT)	109.27	112.69	114.55	116.13	135.36



MATERIAL	%MATERIAL HANDLED	QTY. IN MT
Thermal coal	31	42.26
POL	28	37.81
IRON ORE/PELLET	14	18.51
COKING COAL(IMP)	10	13.43
GYPSUM, LIMESTONE & FLUX	3	4.08
FRM	5	6.86
STEEL	1	2
CONTAINER CARGO	0.19	0
Thermal coal(IMP)	5	6.6
OTHERS	3	3.6

### Logistics Performance Index (LPI) - India's performance



### SAGARMALA PROJECT

The Sagarmala project at Paradip Port represents a paradigm shift in the approach to port development in India, embodying a vision that transcends mere infrastructural upgrades to encompass a holistic strategy for economic growth and regional development. Initially, Paradip Port struggled with inefficiencies, facing challenges such as congestion, limited capacity, and outdated facilities that hampered its ability to meet the demands of a rapidly evolving global trade environment. Recognizing the port's strategic significance in enhancing India's maritime trade, the Sagarmala initiative was launched with the objective of modernizing ports and creating an integrated logistics network.

One of the most impactful aspects of the Sagarmala project at Paradip has been the extensive infrastructure development, which includes the deepening of channels and berths to facilitate the entry of larger vessels, thereby increasing cargo capacity significantly. New multipurpose and specialized

terminals have been constructed to handle a diverse range of cargo types, from bulk to containers, ensuring that Paradip can cater to varied shipping needs. This expansion has not only improved the port's throughput but has also positioned it as a competitive player in the international shipping arena.

Furthermore, the Sagarmala project emphasizes enhancing connectivity, a critical factor for operational efficiency. The integration of the port with national highways, rail networks, and inland waterways through the Gati Shakti Mission has resulted in reduced transit times and costs for cargo movement. This multi-modal connectivity has streamlined logistics, enabling seamless transfer of goods from the port to their final destinations and significantly improving the overall supply chain efficiency.

The project has also embraced technological advancements to optimize operations. The introduction of digital tools for real-time tracking and monitoring of cargo has improved transparency and efficiency. Automation in cargo handling processes has minimized manual interventions, thereby reducing turnaround times and enhancing safety. These technological innovations have transformed Paradip Port into a modern facility capable of meeting the demands of a dynamic global market.

Moreover, the environmental considerations embedded in the Sagarmala project highlight a commitment to sustainability. Initiatives focused on waste management, pollution control, and energy-efficient operations have been implemented to ensure that the port's development aligns with ecological preservation. This approach not only mitigates the environmental impact of port activities but also enhances the port's reputation as a responsible and sustainable entity in the maritime sector.

The economic implications of the Sagarmala project at Paradip are profound. By enhancing port infrastructure and connectivity, the project has catalyzed regional development, creating numerous job opportunities and fostering ancillary industries. Increased trade through the port has spurred local economies, benefiting communities around Paradip and contributing to national economic growth. The strategic development of Paradip Port as a logistics hub has also attracted investment, further solidifying its role in India's trade ecosystem.

In conclusion, the key takeaways from the Sagarmala project at Paradip Port illustrate a comprehensive approach to maritime development that addresses both immediate operational challenges and long-term strategic goals. Through infrastructure modernization, enhanced connectivity, technological integration, and a commitment to sustainability, the project has not only transformed Paradip Port into a key player in global trade but has also set a precedent for future port development initiatives across India. The success of the Sagarmala project serves as a model for leveraging port-led growth to drive economic progress and regional development in the broader context of India's evolving maritime strategy.

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## **GATISHAKTI MISSION**

The Gati Shakti Mission has played a pivotal role in enhancing the operational efficiency and strategic importance of Paradip Port by fostering comprehensive multi-modal connectivity and optimizing logistics. By integrating various modes of transport—such as rail, road, and inland waterways—the mission has created a seamless network that facilitates the swift movement of goods, thereby significantly reducing transit times and logistics costs. This connectivity is crucial for Paradip, as it allows for more efficient cargo handling and distribution, directly addressing previous bottlenecks that hampered the port's growth and capacity.

Moreover, Gati Shakti's emphasis on infrastructure development has led to significant investments in the surrounding logistics ecosystem, including improved access roads and railway links that connect the port to major economic corridors. These enhancements not only promote trade but also attract investments from industries seeking efficient supply chain solutions, thereby reinforcing Paradip's position as a competitive hub in the maritime landscape.

In terms of future trends, the Gati Shakti Mission sets the stage for a digital transformation in port operations. The integration of smart technologies, such as real-time tracking systems and automated cargo handling, will further streamline operations, improving transparency and efficiency. This technological evolution will enable better data-driven decision-making, enhancing the overall management of logistics and supply chains.

Sustainability is another critical aspect that Gati Shakti promotes, aligning with global trends toward greener practices in logistics. Investments in renewable energy sources, waste management systems, and environmentally friendly operational practices will not only reduce the ecological footprint of Paradip Port but also enhance its attractiveness to environmentally conscious businesses.

Overall, the Gati Shakti Mission not only addresses current operational challenges at Paradip Port but also lays a robust foundation for future growth. By prioritizing connectivity, technological innovation, and sustainability, it aims to transform Paradip into a more resilient, efficient, and environmentally responsible logistics hub, setting a benchmark for other ports in India and contributing significantly to the country's economic development.

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## **TECHNOLOGY MODERNISATION AT PARADIP PORT**

Paradip Port Authority (PPA) to work with ID Tech to modernise its facilities with the use of new systems to upgrade gate management and optimise cargo movement. The tracking of inward and outward movement of cargo and people at Paradip Port will be improved through the implementation, operation, and management of an RFID-based Access Control System, along with cloud-based Harbour Entry Permit application software. This will provide real-time monitoring and recording of cargo movements, maintaining security while enabling efficient management and optimisation of port

activities. The system also includes Harbour Entry Permit Application Software hosted on main and local servers, facilitating the issuance of RFID-based permits at various port gates.

Paradip Port, a pivotal maritime hub, is embracing the future of port operations with ID Tech, a leader in advanced automation. In a transformative collaboration, Paradip Port is leveraging ID Tech's cutting-edge solutions to usher in the era of Port 4.0 innovation. This partnership marks a significant milestone in the port's journey towards modernization and efficiency. Paradip Port Authority (PPA) recognizes the need for seamless management of men, material, and vehicles round-the-clock. To meet this demand, PPA has embarked on a mission to modernize gate management systems and optimize cargo movement using latest technologies. Leveraging Tech's solutions, PPA aims to establish intelligent traffic management across the port, significantly elevating operational performance. ID Tech has simplified and modernized the tracking of inward and outward cargo movement by rail/road and movement of people at Paradip Port through the implementation, operation, and management of RFID-based Access Control System along with cloud-based Harbour Entry Permit application software. This innovative solution ensures real-time monitoring and recording of cargo movements, and the system also facilitates 24x7x365 movement of men, material, and vehicles while ensuring stringent security measures are in place enabling efficient management and optimization of port activities. The solution includes Harbour Entry Permit Application Software hosted on main and local servers, facilitating the issuance of RFID-based permits at various port gates. Enhanced security is ensured through RFID readers installed at each gate for identification and recording of vehicle/everyone entering the premises. Furthermore, modernization of weighbridges is achieved with boom barriers and vehicle positioning systems installed at each weighbridge to facilitate seamless and rapid movement of vehicles through the unmanned facility. As Paradip Port embraces the future of port operations, this collaboration with ID Tech Solutions underscores commitment to innovation and excellence. Together, they are paving the way for a more efficient, productive, and technologically advanced maritime hub.

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## CONCLUSION

To sum up, the Paradip Port case study demonstrates how the combination of port automation and multi-modal logistics can greatly improve operating efficiency. Through the integration of many modes of transportation, including road, rail, and sea, Paradip Port has achieved enhanced connectivity with hinterlands, minimized transit times, and streamlined cargo handling. Furthermore, the use of cutting-edge automation technology has reduced operating costs, limited human error, and expedited port operations. Examples of these technologies include automated cargo handling systems and real-time tracking. The case study illustrates how satisfying the increasing needs of international trade while guaranteeing sustainable growth and competitive advantage for ports like Paradip requires leveraging both logistical integration and automation. Other ports wishing to improve their performance in a constantly changing global supply chain can use this strategy as a model.

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