



# Implementation of Warehouse Management System (WMS) in CFS Operation

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## ABSTRACT

The present study is an attempt to study the implementation of a Warehouse Management System (WMS) in the operations of Container Freight Stations (CFS) with special reference to a leading Container Freight Station (CFS) operator at Chennai. The study uses a structured survey instrument that was administered to 60 CFS employees from different departments to assess the effect of WMS on technology adoption, process efficiency, regulatory compliance, cost reduction, and overall operational performance. Statistical tools such as One-Way ANOVA and Chi-Square tests were used to test six hypotheses. The results suggest that the outcomes of WMS implementation were consistently positive across designations, experience levels and departments with no statistically significant differences between groups. The study finds that WMS is a significant enabler of operational excellence in CFS environments, by facilitating the processing of customs documentation, increasing the speed of cargo handling, decreasing manual errors, and increasing customer satisfaction. The paper also indicates training adequacy and regulatory update agility as areas for improvement and provides actionable recommendations for logistics practitioners and policymakers.

**KEY WORD:** Warehouse Management System (WMS), Container Freight Station (CFS), Operational Performance, Process Efficiency, Technology Adoption, Logistics, CFS Operations, RFID, ERP Integration



## INTRODUCTION

The global logistics industry is in the midst of a profound digital transformation, propelled by growing trade flows, the rise of e-commerce, and the imperative for supply chain resilience. The biggest seaports rely on Container Freight Stations (CFS) as an integral part of the ecosystem, serving as intermediate points for consolidating, deconsolidating and customs clearing containerized cargo. However, much of the CFS operations are still based on manual paper processes which are prone to errors, delays and rising costs. Warehouse Management Systems (WMS) — software platforms that track receiving, put-away, inventory, picking, packing and shipping in real time — have become a game changer in tackling these challenges. A good WMS uses barcode scanning, RFID technology and integration with enterprise systems (ERP, TMS) to provide full cargo visibility, reduce turnaround time and improve inventory accuracy. Although the literature on WMS in general warehousing is extensive, empirical research on the implementation of WMS in CFS settings with high customs complexity, regulatory requirements and cargo heterogeneity is scarce. This study fills this research gap by assessing the impact of WMS implementation on operational performance, process efficiency and employee perceptions at a leading CFS operator in Chennai.

## INDUSTRY AND COMPANY CONTEXT

### The Global CFS Landscape

The global Container Freight Station market is anticipated to register a CAGR of approximately 5% during the forecast period (2023-2030). Asia Pacific is expected to be the fastest growing market, with almost 48% of global capacity growth between 2020 and 2030. The main players in the global CFS industry are DHL, Kuehne+Nagel, DB Schenker, DP World and CMA CGM, all of whom have invested heavily in digital infrastructure.

### The Indian CFS Market

The country's container freight market is currently USD 9.5 billion and growing at 10-12% annually. Key growth drivers include the Indian Government's 'Make in India' initiative, rising export volumes of FMCG and pharmaceuticals, and rapid expansion of port capacities at JNPT (Mumbai), Mundra (Gujarat) and Chennai (Tamil Nadu). The Chennai region represents 8-10% of India's total EXIM container traffic and major CFS facilities are operated by leading logistics service providers.

### The Studied CFS Facility, Chennai

The facility under study is one of the leading CFS operators in India, with a network of CFS facilities located at major commercial ports of India. The Chennai CFS, spread across 23 acres, is located just 9 km away from Chennai Port. It handles more than 10,000 TEUs every month, and offers a complete one-stop solution that includes LCL/FCL consolidation and deconsolidation, bonded and non-bonded storage, customs clearance, handling of reefer containers, ODC cargo, and digital logistics services through its proprietary digital platform. The facility is internationally certified by ISO, C-TPAT, AEO, OHSAS 18000 and IMDG compliance.

## REVIEW OF LITERATURE

Rezeki, Syahriza & Nurbaiti (2025) evaluated the Genesis WMS implemented at Lion Parcel's Medan branch, finding measurable improvements in sorting speed, inventory accuracy, and error reduction, while noting constraints related to internet dependency and workforce adaptability to new technology.

Chen & Damian (2024) provided a comprehensive review of warehouse management information systems, highlighting the transformative role of RFID, UWB positioning, cloud computing, and AI — while identifying challenges related to system integration and cybersecurity.

Koesbiandono et al. (2023) investigated WMS and cargo control at Pesaka Loka Kirana's CFS at Tanjung Priok port using SmartPLS-SEM methodology, confirming that WMS significantly improved container freight station efficiency when cargo control was treated as an intervening variable.

Edirisinghe & Liyanage (2021) demonstrated that Extended WMS (EWMS) improved throughput, allocation rates,



receipt rates, and on-time delivery in the FMCG sector — confirming WMS as a lever for operational excellence beyond basic warehousing.

Karunaratna, Vidanagamachchi & Wickramarachchi (2020) developed a readiness model for Industry 4.0 adoption in 3PL warehouses, emphasizing that digital maturity levels and key success factors — including training and infrastructure — directly influence the success of technology implementation.

### **Independent Variables (WMS Implementation Factors)**

The independent variables are the key facilitators of successful implementation of WMS in a CFS environment:

**Technology Adoption (Barcode, RFID):** Deployment of barcode scanning and Radio Frequency Identification (RFID) technologies to provide automated real-time cargo identification and tracking throughout the CFS yard and warehouse floor.

**System Integration (ERP, TMS):** The extent to which the WMS is integrated with Enterprise Resource Planning (ERP) and Transport Management System (TMS) platforms for end-to-end data flow, eliminating the need for redundant data entry and allowing for cross-functional operational coordination.

**Employee Training and Skill Level:** The quality and consistency of WMS training programmes delivered to CFS staff at all levels of designation and the resulting competency levels used to determine how effectively the system is used in daily operations.

**Infrastructure Readiness:** Physical and digital infrastructure must be available and reliable to support WMS deployment (e.g., network connectivity, scanning hardware, server capacity, and power redundancy).

### **Mediating Variable: Process Efficiency Improvement**

Process efficiency is a mediating variable, that transmits the effect of WMS implementation factors to operational performance outcomes. The framework identifies three dimensions of process efficiency improvement:

**Faster Receiving and Dispatch:** Reduction in cargo gate-in to gate-out cycle time. Automated check-in, optimized put-away routing and streamlined dispatch documentation.

**Reduced Manual Errors:** Automated identification technologies and system enforced data validation protocols will help to cut down on data entry errors, mispicks and documentation inaccuracies.

**Improved Workflow:** WMS task assignment and real-time status visibility improve warehouse task sequencing and coordination (cargo receiving, customs examination, stuffing/destuffing, dispatch).

### **Moderating Variables**

There are four moderating variables that moderate the operational outcomes of the implementation of WMS in the context of CFS:

**Cargo Volume:** The more throughput the cargo has, the more the WMS will affect performance. The efficiency gains of the system will be more evident at scale. Benefits of WMS, on the other hand, may be understated during periods of low volume.

**Customs Complexity:** The efficiency benefits of customs modules integrated into the WMS can be enhanced or limited by the type and frequency of customs inspection procedures, documentation requirements, and regulatory interventions.

**Regulatory Compliance:** The pace of changes in customs and trade regulations (e.g. CBIC notifications, AEO requirements) and the complexity of these changes affect the speed at which WMS compliance modules, and thus moderate the overall regulatory performance of the system.

**Workforce Adaptability:** CFS employees' willingness and ability to adopt and effectively use new digital tools, which in turn is a function of previous digital literacy, organizational change management practices and the adequacy of training programmes.

**Dependent Variable:** Operational Performance CFS operational performance – the ultimate dependent variable – is measured along four quantifiable dimensions:

**Inventory Accuracy:** The accuracy of real-time stock records as measured by the frequency of inventory discrepancies and the effectiveness of cycle count processes enabled by the WMS.

**Turnaround Time:** Total time taken from cargo arrival at the CFS gate to final delivery or completion of customs clearance – a KPI for CFS competitiveness. **Cost Reduction:** Quantifiable savings in labour costs, error-induced rework costs, storage costs and documentation overheads due to WMS-driven process automation and optimisation. **Customer Satisfaction:** The perceived quality of the CFS service by importers, exporters and freight forwarders regarding the speed, accuracy, transparency and reliability of the cargo handling and documentation services. The framework implies that the higher the WMS implementation (independent variables) the higher the process efficiency (mediating) and the higher the operational performance (dependent). Moderating variables affect the strength of these relationships. This conceptual model is illustrated in Figure 1 below.

### Conceptual Framework

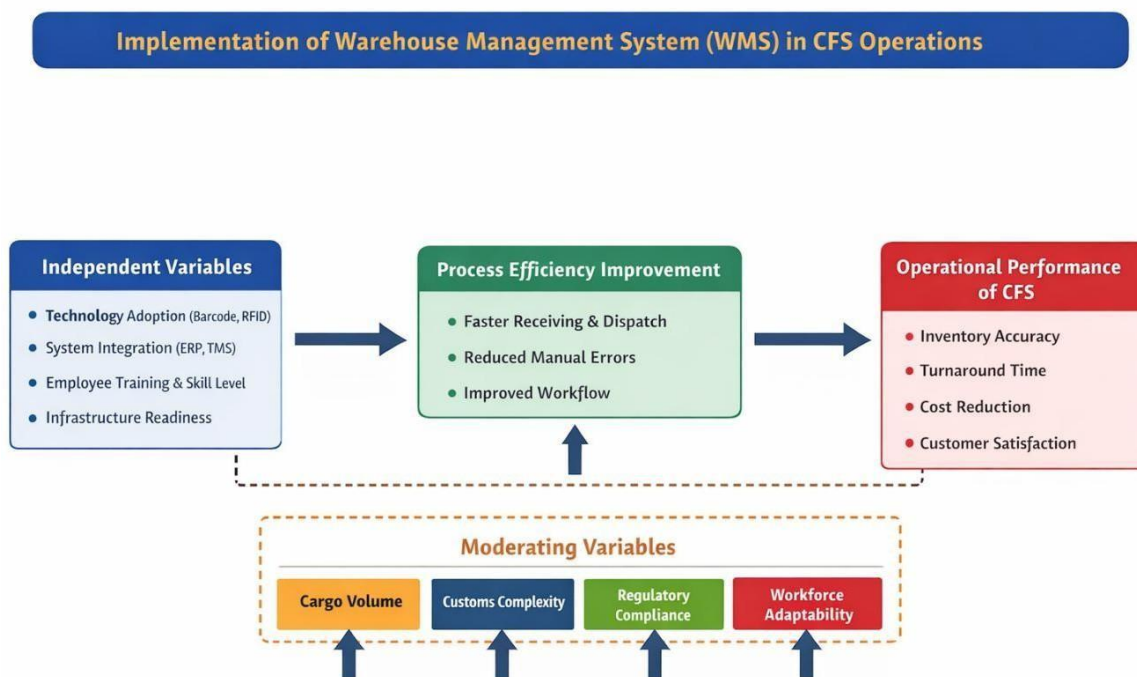


Figure1

## RESEARCH METHODOLOGY

### Research Design

The research design adopted for the study was descriptive-cum-analytical. The structured questionnaire was administered on 60 respondents at the CFS facility studied at Chennai during the period of January to April 2026 using 5-point Likert scale. The questionnaire consisted of demographic variables (designation, department, experience, operations handled) and conceptual framework variables categorized under four independent variables (technology adoption, system integration, employee training, infrastructure readiness), one mediating variable (process efficiency), three moderating variables (cargo volume, customs complexity, workforce adaptability), and one dependent variable (operational performance). A structured questionnaire administered on a 5 point Likert scale was used for 60 respondents of the studied CFS facility, Chennai during January to April 2026. The questionnaire had demographic variables (designation, department, experience, operations handled) and conceptual framework variables structured on four independent variables (technology adoption, system integration, employee training, infrastructure readiness), one



mediating variable (process efficiency), three moderating variables (cargo volume, customs complexity, workforce adaptability) and one dependent variable (operational performance).

### Sample Composition

<b>Designation</b>	Executive	15 (25%)
	Manager	12 (20%)
	Supervisor	10 (17%)
	Operations Staff	18 (30%)
	Other	5 (8%)
<b>Department</b>	Custom Clearance & Examination	20 (33%)
	Cargo Handling	15 (25%)
	Consolidation (Export)	14 (23%)
	De-consolidation (Import)	11 (18%)
<b>Experience</b>	Less than 2 years	22 (37%)
	2–5 years	20 (33%)
	5–8 years	12 (20%)
	More than 8 years	6 (10%)

### Statistical Tools

Data was analyzed using IBM SPSS Statistics. The following techniques were used:

- Percentage Analysis – for demographic profiling.
- Descriptive Statistics (Mean, Standard deviation) – for the analysis of response pattern
- One-Way ANOVA – to test for mean differences across designation, experience and department groups
- Chi-square test – to examine the relationship between demographic factors and perceptions of WMS

### KEY FINDINGS

#### WMS Adoption: Strongly Positive Across All Dimensions

For all 26 Likert-scale questions, between 65% and 78% of respondents agreed or strongly agreed with positive outcomes of the WMS. The highest agreement was for manual error reduction (75%), cargo handling speed improvement (75%), inventory accuracy (71%) and service reliability (77%). The results show a high and wide employee satisfaction with the performance of WMS.

#### ANOVA Results: Uniform Performance Across Groups

H1 (ANOVA)	Designation × Op. Performance	0.474	0.755	Fail to Reject Ho	No significant difference
H2 (ANOVA)	Experience × Op. Performance	0.839	0.478	Fail to Reject Ho	No significant difference



H3 (ANOVA)	Department × Process Efficiency	0.549	0.651	Fail to Reject H <sub>0</sub>	No significant difference
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None of the three ANOVA tests rejected the null hypothesis ( $p > 0.05$ ) confirming that the benefits of WMS are experienced equally across employee roles, tenure and departments. This is an important finding, which confirms the democratising effect of WMS technology across the organisation.

### Chi-Square Results: Perception Consistency Across Groups

H4 (Chi-Square)	Designation × Real-time Tracking	26.022	0.054*	Fail to Reject H <sub>0</sub> (Borderline)
H5 (Chi-Square)	Experience × Manual Error Reduction	8.830	0.717	Fail to Reject H <sub>0</sub>
H6 (Chi-Square)	Department × Customs Documentation	7.269	0.839	Fail to Reject H <sub>0</sub>

Chi-Square tests (H4, H5, H6) verified there is no statistically significant association between demographic variables and perceptions of WMS. The borderline finding for Hypothesis 4 (Designation X Real-time Tracking,  $p = 0.054$ ) points to a marginal trend that warrants monitoring – staff at the operations level with daily interaction with barcode/RFID systems may develop distinct perceptions of tracking effectiveness relative to managerial personnel. The borderline result for Hypothesis 4 (Designation × Real-time Tracking,  $p = 0.054$ ) suggests a marginal trend to monitor — operations-level staff who interact with barcode/RFID systems on a daily basis may view tracking effectiveness differently than managerial personnel.

### Notable Positive Outcomes

- 75% agreement — highest performing WMS outcome: Reduction in manual errors
- 77% agreement: Reliability of service increasing customer confidence
- 75% agreement: Improvement in cargo handling speed
- 72% agreement: Simplification of customs documentation
- 73% agreement: Real-time inventory accuracy
- Service reliability instills customer confidence: 77% agree
- Speed of handling cargo improved: 75% agreement
- Customs documentation simplification: 72% agree
- Real time inventory accuracy: 73% agreement

### Areas of Relative Weakness

- The most common neutral response (30%) was employee training adequacy indicating inconsistency in training delivery across teams.
- Agility of regulatory updates had the lowest combined agreement rate (60%) and the highest neutral rate (27%) indicating perceived delays in system adaption to changing customs regulations

### DISCUSSION

The results of this study are consistent and extend literature on WMS effectiveness. In line with Edirisinghe & Liyanage (2021) and Rezeki et al. (2025), the deployment of WMS at the CFS under study has resulted in significant operational



benefits concerning speed, accuracy, cost efficiency and customer satisfaction. This is particularly evident in the homogeneity of benefits across designation and experience groups confirmed by ANOVA. The CFS environment seems to alleviate adoption effects, unlike general warehousing literature that occasionally reports experience-dependent learning curves, perhaps due to the structured, role-specific workflows of the WMS platform. The borderline chi-square result for designation versus perception of real-time tracking ( $p = 0.054$ ) is consistent with Karunarathna et al. (2020) who found that frontline workers in digital environments develop a different operational awareness than supervisory staff. This has immediate implications for the design of WMS training and feedback loops. The identified training gap (30% neutral) echoes Rezeki et al.'s (2025) concern about human resource adaptability — confirming that technology deployment alone is not enough without a parallel investment in capacity building. Meanwhile, the weakness in the regulatory update has underscored the need for better integration of WMS compliance modules with India's Customs EDI system (ICEGATE), particularly given the velocity of notifications from CBIC. The study has focused on one large CFS operator in Chennai. How scalable is this study? Will smaller CFS operators or CFS operators in port cities with different cargo profiles (e.g. Mundra for bulk commodities, Kolkata for East India transit cargo) produce different results? This dimension is to be explored in future multi-site studies.

## SUGGESTION AND RECOMMENDATION

### For CFS Operators

- Introduce structured WMS onboarding and quarterly refresher training, especially for the 37% of respondents that have less than 2 years of experience, to turn neutral perceptions into confident usage.
- Create a dedicated Regulatory Technology (RegTech) sub-team to ensure real-time synchronization of WMS compliance modules with CBIC/ICEGATE notifications, reducing the regulatory agility gap.
- Use the data analytics capabilities of the WMS platform for predictive cargo flow modelling, to enable proactive staffing and space allocation decisions.
- Invest in IoT-enabled smart yard management, including automated gate OCR, drone-based inventory checks and AI-assisted bottleneck detection, to extend WMS benefits beyond the warehouse floor.

### For Policymakers and Logistics Regulators

- The Ministry of Commerce should develop standardized WMS API specifications for CFS– Customs integration, reducing the cost and complexity of regulatory compliance for small and medium CFS operators.
- Port Trusts and Customs authorities should provide incentives for AEO-certified CFS operators demonstrating WMS-enabled documentation accuracy, further reducing inspection overhead and turnaround time.
- Port Trusts and Customs authorities should encourage AEO-certified CFS operators who demonstrate WMS-enabled document accuracy, thus reducing inspection overhead and turnaround time further.

### For Future Research

- Increase the sample size to include multiple CFS branches and comparative studies among other CFS operators in Chennai, JNPT and Mundra.
- Investigate the mediating role of process efficiency between WMS implementation and operational performance using Structural Equation Modelling (SEM).
- Investigate the moderating effects of cargo volume seasonality and customs complexity on WMS effectiveness using longitudinal datasets.
- Investigate the mediating role of process efficiency in the relationship between WMS



implementation and operational performance using Structural Equation Modelling (SEM).

- Investigate the moderating role of seasonality of cargo volume and customs complexity on WMS effectiveness employing longitudinal datasets.

## CONCLUSION

This study gives empirical evidence that the implementation of Warehouse Management System at the studied CFS facility, Chennai has brought about wide spread significant improvements in operational performance, process efficiency, regulatory compliance and customer satisfaction. Six hypotheses tested through ANOVA and Chi-Square analyses cumulatively supported that WMS benefits are not segregated based on employee designation, experience or departmental affiliation – a fact that underscores the institutional, systemic impact of the technology. The CFS industry in India is grappling with intense competition from Direct Port Delivery, growing complexity in e-commerce cargo and the rapid pace of customs digitisation. Thus, WMS has become a strategic imperative, not just an operational convenience. The return on investment, usually realized in 12-24 months after implementation, further strengthens the case for WMS adoption as a financially sound decision for logistics operators of any size. The digital platform of the studied facility, which provides a faceless, contactless and paperless service model, is a blueprint for the future of CFS operations in India. By bridging the gaps identified in training consistency and regulatory responsiveness, the company – and the wider CFS sector – will be well-positioned for continued growth in a challenging global logistics environment.

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