

Assessment Of The Impact Of Advanced Technology On Inland Container Depots (ICDs) Operational Efficiency. (A Case of Hesu ICD)

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DOI: 10.29322/IJSRP.15.10.2025.p16608
<https://dx.doi.org/10.29322/IJSRP.15.10.2025.p16608>

Paper Received Date: 15th August 2025
Paper Acceptance Date: 26th September 2025
Paper Publication Date: 6th October 2025

Abstract

Inland Container Depots (ICDs) are vital in enhancing trade logistics by decongesting seaports, facilitating customs clearance, and improving cargo flow. However, in Tanzania, ICDs face challenges of inefficiency, delays, and high operational costs, often linked to limited adoption of modern technologies. This study assesses the impact of advanced technology on the operational efficiency of Inland Container Depots (ICDs), using HESU Depot in Tanzania as a case study. The specific objectives were to examine the role of automated container tracking systems in improving operational efficiency, to determine the impact of electronic data interchange (EDI) on coordination within ICD operations, and to determine the contribution of inventory management systems (IMS) to ICDs operational efficiency. A sample of 68 respondents from Hesu Depots, Logistics and Transportation company, and Government officials. Data were collected through structured questionnaires and interviews from ICD staff, management, Government officials, logistics firms, and customers. Analytical techniques included descriptive statistics, reliability tests, and multiple regression models through the SPSS software version 27. Findings reveal that automated container tracking systems, EDI, and IMS significantly enhance operational efficiency by improving throughput, reducing container dwell time, minimizing errors, and increasing labor productivity. The study concludes that automated container tracking systems, EDI, and IMS significantly enhance ICD efficiency by improving cargo handling speed, reducing delays and errors, increasing inventory accuracy, and boosting labor productivity. Based on these findings, it is recommended ICDs should increase investment in advanced container tracking technologies such as GPS-enabled tracking, RFID, and real-time monitoring platforms. This will reduce delays, improve container visibility, and minimize operational costs.

1.0 Introduction

In today's rapidly evolving global economy, advanced technology plays a transformative role in enhancing efficiency, reducing costs, and improving service delivery across various industries Notteboom & Rodrigue, (2020). The logistics and transportation sector, in particular, has greatly benefited from technological advancements, enabling faster cargo handling, real-time tracking, and improved operational efficiency. Countries that have embraced modern technology in their logistics infrastructure have witnessed significant improvements in trade facilitation and economic growth García et al., (2019).

For instance, in the Netherlands, the Port of Rotterdam has integrated AI-driven logistics systems, which have optimized container movements and reduced vessel turnaround times by 20%, improving trade efficiency. Similarly, Singapore's Smart Port has adopted IoT-based cargo tracking, reducing cargo clearance times by 40% and strengthening its position as a global logistics hub (World Bank, 2022).

In Africa, Kenya's Standard Gauge Railway (SGR), integrated with smart logistics systems, has shortened cargo transit between Mombasa and Nairobi, greatly improving freight efficiency (Mwaura & Nyaberi, 2019). In contrast, Tanzania's slow adoption of such technologies at ICDs continues to contribute to longer dwell times, port congestion, and higher logistics costs.

Tanzania continues to face challenges in adopting and integrating advanced technology into logistics and transport infrastructure. According to the World Bank (2022), inefficient logistics in sub-Saharan Africa add up to 40% to trade costs, making imports and exports more expensive. Tanzania's logistics sector struggles with outdated manual processes, inadequate investment in digital infrastructure, and limited access to skilled ICT professionals, all of which contribute to increased cargo dwell times, congestion at key trade hubs, and reduced global competitiveness Mwaura & Nyaberi, (2019).

However, Mchopa and Chileshe (2021) emphasize that insufficient investment in ICT training and infrastructure remains a major constraint in Tanzania's logistics sector. This gap undermines the efficiency of ICDs, ports, and the broader supply chain, resulting in longer dwell times, higher operational costs, and diminished trade competitiveness. Therefore, equipping employees with the necessary skills and knowledge to effectively operate emerging technologies is crucial for successful adoption and sustainable implementation. by 15% and improved logistics transparency (Christopher, 2016). These examples demonstrate the significant role technology plays in improving ICD efficiency.

By selecting Hesu ICD as the case study, the research can provide a comparative analysis with Kenya's ICD, which has seen significant improvements in efficiency due to the adoption of electronic cargo tracking and automated systems (Mwaura & Nyaberi, 2019). Similarly, insights can be drawn from South Africa's Durban Port, where cloud-based logistics platforms have improved operational speed (Notteboom & Rodrigue, 2020). By comparing the initiatives in these regions with the current technological landscape at Hesu ICD, this study will shed light on both best practices and gaps in technology implementation in Tanzania's ICDs.

2.0 Literature review

2.1 Empirical Review

The role of automated cargo tracking systems in improving operational efficiency in ICDs.

According to Notteboom & Rodrigue, 2020 analyzed the impact of digitalization and automation on global port and ICD efficiency. The study found that automated container tracking, AI-driven logistics, and blockchain-based documentation reduced processing times by 30% and improved security in international shipping. As ports and ICDs adopted digital systems, cybersecurity risks increased. The study emphasized the need for strong cybersecurity measures to prevent cyberattacks on logistics networks.

According to Wang *et al.* (2019) conducted a study on smart port technology in Asia and found that real-time data analytics and IoT-based monitoring improved container handling efficiency by reducing turnaround times by 40%. The integration of Electronic Data Interchange (EDI) and blockchain-based trade documentation improved cross-border trade efficiency, reducing cargo clearance time by 35%. The study found that delays in customs procedures were a major bottleneck in ICD performance, but digitalization helped streamline processes.

The impact of electronic data interchange (EDI) on the coordination of ICD operations.

According to European Maritime Study (2020). IoT-enabled container tracking sensors reduced cargo loss by 60% and improved inventory management by 25%. Smart port systems integrated with IoT improved overall shipping efficiency by 20%. These global findings establish the positive impact of modern technology on ICDs performance. However, the level of implementation and adoption in Tanzania's ICDs remains a critical area of investigation.

The Role of Information Systems Usage in Enhancing Port Logistics Performance: The Case of Dar es Salaam Port in Tanzania by Mafuru, & Mtenzi, (2018) The study found that the adoption of information systems at Dar es Salaam Port led to significant improvements in logistics performance. The implementation of these systems reduced cargo dwell time and streamlined customs procedures, enhancing overall port efficiency. Also, despite the benefits, challenges such as inadequate training for staff and resistance to change were noted as barriers to effective implementation.

According to Rengamani (2018), EDI adoption in the shipping and logistics industry has led to faster information access and improved efficiency in customs operations. Electronic Data Interchange (EDI) facilitates seamless communication between stakeholders in the logistics chain, including shipping lines, freight forwarders, customs authorities, and depot operators. This integration reduces manual data entry, minimizes errors, and accelerates the processing of documentation.

The contribution of inventory management systems to ICD Operations efficiency.

A study by Shintani et al. (2017) developed a model for empty container allocation without prior knowledge of demand probability distributions. This model utilizes a differential evolution algorithm and the largest-debt-first policy to optimize the allocation of self-owned and leased containers across inland freight stations. The findings indicate that this approach effectively reduces operational and management costs, particularly in scenarios with high demand fluctuations.

A study by Eze et al. (2021) investigated the effect of inventory management systems on operational performance. The findings indicated that the failure to maintain proper and accurate inventory control management negatively impacts profitability and performance, underscoring the importance of effective IMS in enhancing operational efficiency.

Research by Chou et al. (2021) explored the integration of Strategic Management Accounting (SMA) and Management Accounting Information Systems (MAIS) in inventory management. The study found that combining SMA with MAIS enhances decision-making processes, leading to improved inventory control and operational efficiency in logistics operations

3.0 Research methodology

3.1 Research Design

This study adopted a case study design with a strong quantitative analysis component. The study focused on understanding the real-world context and dynamics of Inland Container Depot (ICDs) operations efficiency it also utilized structured questionnaires to collect quantifiable data, which were analyzed statistically. According to Saunders et al., (2019), case study design is appropriate when the researcher seeks to explore "how" or "why" a complex process or event occurs especially when the boundaries between the phenomenon and its context are not clearly defined.

3.2 Data Collection Methods

This study uses the questionnaire and interview, the questionnaire gather data from Hesu Depots, Structured or semi-structured questionnaires can include Likert scale questions, multiple-choice questions, and open-ended responses. Also, The interviews conducted to gather qualitative insights from key stakeholders involved in the operation and management of Inland Container Depots (ICDs) in Tanzania.

3.3 Data Analysis

This study uses the descriptive statistics, reliability tests, and multiple regression models through the SPSS software version 27 in order to analyze data.

4.0 Findings and Discussions

4.1 The role of automated container tracking systems in improving operational efficiency in ICDs.

The study aimed to determine the role of automated container tracking systems in improving operational efficiency in ICDs. The data clearly demonstrates that stakeholders overwhelmingly perceive, these systems allow real-time monitoring of container movements from arrival to dispatch, improving visibility across the logistics chain and reducing misplacement, delays, and manual follow-ups. By providing accurate, up-to-date information, automated tracking systems support better decision-making, coordination among staff, and resource allocation.

Table 4. 1: showing an analysis regarding the role of automated container tracking systems in improving operational efficiency in ICDs.

Attribute	Mean	Standard Deviation
Enhances real-time tracking	4.31	0.69
Enhances coordination	4.29	0.71
Reduces operational costs	4.28	0.73
Enhances security	4.27	0.72

Source: Statistical Data,2025

The finding in Table 4.1 indicates that Real-time tracking reduces delays and misplacement recorded a mean score of 4.31 with a standard deviation of 0.69. This indicates that respondents strongly agree that automated container tracking systems significantly reduces delays and misplacement within the ICD. Implication for Operational Efficiency, this finding implies that the adoption of automated tracking systems plays a critical role in reducing turnaround times, and improving throughput at ICDs. Faster container handling directly contributes to enhanced operational efficiency, better service delivery, and improved coordination within the depot. Similar findings have been reported by Musa and Kibet (2021) and Nguyen and Waring (2021), who observed that real-time container tracking significantly improves handling speed and overall depot efficiency by reducing manual tracking errors and streamlining workflow.

"Since implementing the automated container tracking system, we have noticed a significant reduction in delays and misplacements. Containers move through the depot much faster, and we can monitor their location in real time, which has greatly improved our operational efficiency." – ICD Manager, HESU ICD

Also, Tracking enhances coordination between staff and stakeholders recorded a mean of 4.29 with a standard deviation of 0.71. The mean value above 4 indicates that respondents generally agree to strongly agree that automated container tracking systems improve

coordination among ICD staff and external stakeholders. The standard deviation of 0.71 shows a moderate consistency in responses, suggesting that most respondents share similar views about the system's impact on coordination. Implication for Operational Efficiency. By providing real-time updates on container movements, automated tracking systems facilitate better communication between staff, transporters, port authorities, and customers. This reduces misunderstandings, and ensures that operations are smoothly synchronized, contributing to improved operational efficiency. Nguyen and Waring (2021) emphasize that real-time tracking systems enhance operational coordination in depots by improving information flow and ensuring that all stakeholders are aware of container locations and processing status.

"Tracking systems make it easier for our staff and external stakeholders to work in sync. Everyone has access to the same real-time information, which reduces misunderstandings and improves coordination." - ICD Technology Experts (IT)

The results show that respondents strongly agreed that the use of automated container tracking systems significantly contributes to the reduction of operational costs in Inland Container Depots (ICDs), as indicated by a high mean score of 4.28 on a 5-point Likert scale. This suggests that automation minimizes expenses associated with manual operations, fuel usage, and container misplacement. The relatively low standard deviation of 0.73 indicates that respondents' opinions were fairly consistent, with little variation in their responses. The finding implies that container tracking technologies create cost efficiency by streamlining container movements, reducing idle time, and lowering re-handling costs. This aligns with the views of Gunasekaran and Ngai (2018), who argue that automation in logistics leads to both direct and indirect cost savings through improved resource utilization. Additionally, an ICD machine operator confirmed in an interview that:

"With the automated tracking and handling systems, we use less fuel, spend less time moving containers around, and avoid unnecessary rework. This has really cut down the operational costs for the depot." - ICD Machine Operator

The analysis indicates that respondents strongly agreed that automated container tracking systems enhance security within ICD operations, as reflected by the high mean score of 4.27. This suggests that the majority of respondents recognize the system's effectiveness in monitoring container movements, minimizing risks of theft, tampering, and unauthorized access. The standard deviation of 0.72 shows that responses were relatively consistent, meaning most participants shared similar views on the security benefits of container tracking systems. This aligns with previous studies such as Nguyen & Waring (2021), who argued that container tracking systems improve visibility and accountability, making it easier to detect irregularities in cargo movement.

"Automated container tracking has greatly enhanced security in our depot. Every container's movement is visible and recorded, which discourages theft or unauthorized handling." - ICD Manager

4.2 The impact of electronic data interchange (EDI) on the coordination of ICD operations

The study aimed to determine the impact of Electronic Data Interchange (EDI) on the coordination of operations within Inland Container Depots (ICDs). EDI reduces manual errors, accelerates document processing, and ensures that all parties have access to accurate, real-time data. Assessing its impact on interdepartmental coordination, error reduction, transparency, and accountability provides insights into how technological integration can enhance the overall efficiency and effectiveness of ICD operations.

Table 4. 2: showing an analysis regarding the impact of electronic data interchange (EDI) on the coordination of ICD operations.

Item	Mean	Standard Deviation
Improves document processing speed	4.36	0.68
Reduces errors and inconsistencies	4.32	0.70
Enhances interdepartmental coordination	4.29	0.71
Improves transparency and accountability	4.31	0.69

Source: Statistical Data, 2025

The finding in Table 4.2 indicate that majority of respondents agreed that EDI significantly improves the speed of document processing at Inland Container Depots (ICDs). The high mean score of 4.36 suggests that most respondents rated this factor as either agreed. This demonstrates that EDI minimizes the delays associated with manual paperwork, such as customs clearance forms, bills of lading, and cargo release documents. The relatively low standard deviation (0.68) reflects a high level of consensus among respondents, meaning that views were generally consistent. Faster document processing is particularly critical in ICDs, where cargo handling and clearance efficiency directly impact turnaround times and overall service quality. These findings align with Nguyen and Waring (2021), who noted that automation of document exchange through EDI reduces bottlenecks in supply chain communication, thereby accelerating service delivery. Similarly, *Tijan et al.* (2019) emphasized that EDI contributes to leaner and more responsive logistics operations by cutting down administrative workload.

“Since the introduction of EDI, the time taken to process shipping and customs documents has reduced drastically. We can now serve clients faster and avoid unnecessary delays.” - ICD documentation officer

Also, “EDI reduces errors and inconsistencies” recorded a mean of 4.32 with a standard deviation of 0.70. Interpretation, A mean above 4 indicates that respondents strongly agree that EDI significantly minimizes errors and inconsistencies in cargo documentation at the ICD. The standard deviation of 0.70 shows a moderate level of consistency, indicating that most respondents share a similar perception of EDI’s effectiveness in reducing documentation errors. Implication for Operational Coordination, By automating the exchange of cargo information, EDI reduces manual entry mistakes, prevents duplications, and ensures consistency in data shared among departments and external stakeholders. This fosters better operational coordination and faster decision-making, ultimately improving depot efficiency. These findings are Supported by Bichou and Gray (2020) and Gunasekaran and Ngai (2018) emphasize that EDI systems enhance accuracy in logistics documentation, reduce administrative errors, and strengthen communication flow between ICDs, customs, and port authorities.

“Before EDI, we experienced frequent mismatches in cargo data, which caused unnecessary delays. With the system now, errors are minimal, and verification is quicker.” - customs officer

Also, “EDI enhances interdepartmental coordination” recorded a mean of 4.29 with a standard deviation of 0.71. Interpretation, The mean above 4 indicates that respondents generally agree to strongly agree that EDI improves coordination among different departments within the ICD. The standard deviation of 0.71 shows a moderate consistency in responses, indicating that most respondents

share similar perceptions about EDI's role in interdepartmental coordination. Implication for Operational Efficiency, EDI allows real-time sharing of cargo and operational information between departments, reducing miscommunication and delays. This ensures that all departments such as documentation, cargo handling, and warehousing are aligned, leading to smoother workflow and improved overall depot efficiency. These findings are supported by Gunasekaran and Ngai (2018), EDI systems facilitate seamless information flow across organizational units, strengthening coordination, reducing operational bottlenecks, and improving service delivery in container depots.

“EDI has greatly improved coordination between departments. Everyone has access to real-time information, which reduces delays and prevents miscommunication. Tasks that used to take hours or require multiple follow-ups can now be completed much faster and more efficiently.” - An ICD systems administrator

Furthermore, “EDI improves transparency and accountability” has a mean of 4.31 and a standard deviation of 0.69. Interpretation, The mean above 4 indicates that respondents strongly agree that EDI enhances transparency and accountability in ICD operations. The standard deviation of 0.69 shows that responses are highly consistent, indicating strong consensus among respondents about the benefits of EDI. Implication for ICD Operations, EDI ensures that all documentation and data exchanges are digitally recorded, traceable, and accessible, reducing opportunities for errors, manipulation. This transparency supports better decision-making and accountability between departments and external stakeholders such as customs and port authorities. These findings are supported by Bichou and Gray (2020) and Gunasekaran and Ngai (2018) note that EDI systems improve auditability, operational oversight, and transparency in container depots, which strengthens trust and efficiency in logistics operations.

“With EDI, all transactions and document exchanges are recorded digitally. This makes it easy to track who handled each process, reducing the chances of errors or manipulation. It has made operations more transparent and has increased accountability among staff and departments.” - An ICD operations officer

4.3 The contribution of inventory management systems to ICD Operations efficiency.

The study aimed at determine the contribution of inventory management systems to ICD Operations efficiency. MS are critical technological tools that help depots track, manage, and control cargo effectively, ensuring smooth operations and reducing manual errors. Based on the survey findings, respondents strongly agreed that IMS positively impacts ICD efficiency across multiple dimensions.

Table 4.3: showing an analysis regarding the contribution of inventory management systems to ICD Operations efficiency.

Item	Mean	Standard Deviation
Improves accuracy of inventory records	4.34	0.70
Reduces cargo dwell time	4.30	0.72
Increases throughput	4.28	0.71
Enhances labor productivity	4.29	0.70

Source: Statistical Data,2025

The finding in Table 4.6 indicates that “IMS improves accuracy of inventory records” recorded a mean of 4.34 with a standard deviation of 0.70. Interpretation, The mean above 4 indicates that respondents strongly agree that Inventory Management Systems (IMS) enhance the accuracy of container and cargo records in ICDs. The standard deviation of 0.70 shows a moderate level of consistency

among respondents, reflecting general consensus on the effectiveness of IMS. Implication for Operational Efficiency, Accurate inventory records reduce errors in container tracking, minimize lost or misplaced cargo, and enable smoother coordination between storage, handling, and dispatch processes. This directly contributes to enhanced throughput, reduced dwell time, and better service quality. These findings are supported by Lam and Bai (2016) emphasize that implementing IMS improves data accuracy in depot operations, reduces operational bottlenecks, and strengthens decision-making for logistics and inventory management.

"Since implementing the inventory management system, we have been able to track every container in real time. Errors in record-keeping have significantly decreased, and it is much easier to locate and verify shipments without relying on manual logs." - An ICD inventory officer

Also, "IMS reduces cargo dwell time" recorded a mean of 4.30 with a standard deviation of 0.72. Interpretation, A mean above 4 indicates that respondents strongly agree that Inventory Management Systems (IMS) help in minimizing the time cargo spends at the ICD before clearance or dispatch. The standard deviation of 0.72 suggests a moderate consistency in responses, showing general agreement among participants. Implication for Operational Efficiency, IMS optimizes storage, retrieval, and inventory tracking processes, which prevents congestion in storage areas, and accelerates container handling. Shorter dwell times improve depot throughput and client satisfaction. Heilig et al. (2017) argue that effective inventory management systems streamline operations, reduce bottlenecks, and facilitate faster cargo turnover, thus enhancing overall operational performance in ICDs.

"The inventory management system has been very effective in reducing cargo dwell time at our depot. It allows us to track containers accurately and locate them quickly, so goods spend less time waiting for processing or clearance. This not only speeds up operations but also improves customer satisfaction, as shipments move through the depot more efficiently." - ICD Operations Manager

Also, "IMS increases throughput" recorded a mean of 4.28 with a standard deviation of 0.71. Interpretation: The mean above 4 indicates that respondents strongly agree that Inventory Management Systems (IMS) enhance the volume of containers processed over a given period. The standard deviation of 0.71 shows moderate consistency, suggesting general agreement among respondents regarding the positive impact of IMS on throughput. Implication for Operational Efficiency, IMS facilitates efficient tracking, storage, and retrieval of containers, enabling ICDs to handle a larger volume of cargo without delays. Increased throughput contributes to faster operations, reduced congestion, and improved customer satisfaction. Lam and Bai (2016) and Heilig et al. (2017) highlight that advanced inventory management systems streamline operations, optimize space utilization, and improve container flow, leading to higher throughput in depots.

"With the inventory management system in place, containers move in and out of the depot much faster. The system alerts us when cargo is ready for dispatch, which has significantly reduced the time containers spend idle in the yard." - An ICD operations supervisor

Lastly, "IMS enhances labor productivity" recorded a mean of 4.29 with a standard deviation of 0.70. Interpretation, the mean above 4 indicates that respondents strongly agree that Inventory Management Systems (IMS) improve labor productivity in ICDs. The standard deviation of 0.70 suggests a moderate consistency in responses, reflecting broad agreement among respondents on IMS's impact. Implication for Operational Efficiency: IMS reduces manual tasks such as physical record-keeping and manual inventory checks. This allows staff to focus on higher-value tasks, streamlines operations, and enhances overall productivity within the depot. Support

from Literature by Heilig et al. (2017) and Lam and Bai (2016) emphasize that IMS implementation reduces labor-intensive processes, improves operational efficiency, and increases workforce productivity in logistics operations.

“The inventory management system automates routine tasks like recording container movements and updating stock levels. This allows staff to focus on more critical activities, which has improved overall productivity.” - A Yard supervisor

5.0 Conclusion and recommendation

Conclusion of Findings

The study aimed to assess the impact of advanced technologies on the operational efficiency of Inland Container Depots (ICDs), with a particular focus on automated container tracking systems, electronic data interchange (EDI), and inventory management systems (IMS). Based on the analysis of survey data, interviews, and statistical results, the following conclusions were drawn, the findings revealed that automated container tracking systems significantly enhance ICD operational efficiency. Respondents strongly agreed that these systems improve the speed of container handling, reduce delays and misplacements, enhance coordination among staff and stakeholders, and contribute to cost reduction. The mean values, all above 4.20, indicate high agreement that container tracking systems are critical in minimizing inefficiencies and ensuring timely cargo movement.

Recommendations of the study

Based on the findings and conclusions, this study provides the following recommendations to enhance operational efficiency in Inland Container Depots (ICDs) through the adoption of advanced technologies, ICDs should increase investment in advanced container tracking technologies such as GPS-enabled tracking, RFID, and real-time monitoring platforms. This will reduce delays, improve container visibility, and minimize operational costs. Training staff to effectively use these systems will further enhance coordination and service delivery.

The study recommends that ICDs fully integrate EDI into their daily operations to streamline communication and documentation processes. This will help minimize manual paperwork, reduce errors and inconsistencies, and foster real-time coordination between departments and external stakeholders such as shipping lines, port authorities, and customs agencies. Additionally, ICDs should ensure that EDI platforms are compatible with regional and international logistics systems to improve interoperability. ICDs should implement robust IMS that can accurately track cargo movement, optimize storage space, and reduce dwell time. Regular system upgrades and capacity-building programs for staff are necessary to ensure accurate inventory records and improved throughput. Leveraging artificial intelligence (AI) and predictive analytics within IMS could further enhance decision-making and demand forecasting.

ICD management should invest in continuous training and upskilling of staff. Building ICT literacy and technical know-how among employees will ensure efficient system utilization and minimize operational disruptions. Also, Government and regulatory bodies should provide enabling policies and infrastructure support for ICDs to adopt advanced technologies. This includes establishing favorable ICT policies, investing in reliable internet connectivity, and offering financial incentives or subsidies to encourage technological innovation within the Logistics and Transportation sector. ICDs should establish mechanisms for continuous monitoring and evaluation of technological systems to ensure optimal performance.

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