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MECHANISMS OF CONSTRUCTION LOGISTICS OPTIMIZATION FOR RESIDENTIAL CONSTRUCTION MATERIALS ACROSS FCT, NIGERIA

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ABSTRACT

Construction material waste remains a major challenge affecting project cost, productivity, and sustainability within residential construction projects in Nigeria. This study examined the mechanisms of construction logistics optimization for residential construction materials across the Federal Capital Territory (FCT), Nigeria, intending to identify logistics optimization mechanisms adopted by construction firms, determining factors contributing to material waste generation, assessing the effectiveness of logistics optimization practices, and evaluate strategies for improving sustainable construction logistics. A mixed-method research design was adopted, combining structured questionnaires administered to 389 construction professionals with Key Informant Interviews (KIIs). Quantitative data were analysed using descriptive statistics, the Relative Importance Index (RII), and multiple regression analysis, while qualitative responses were analysed thematically. The findings revealed that Site Material Control Systems (RII = 0.924), Supplier Coordination Mechanisms (RII = 0.910), and Inventory Management Systems (RII = 0.896) were the most widely adopted logistics optimization mechanisms. Poor Material Handling (RII = 0.942), Material Damage During Transportation (RII = 0.930), and Inadequate Storage Facilities (RII = 0.916) emerged as the leading causes of material waste. Regression analysis further confirmed that construction logistics optimization mechanisms significantly influence material waste reduction (R^2 = 0.659; $p < 0.001$). The study concludes that strengthening logistics planning, adopting digital logistics technologies, and implementing lean construction practices can substantially reduce

material waste, improve operational efficiency, and promote sustainable residential construction in Nigeria.

KEYWORDS: Construction Logistics Optimization; Material Waste Reduction; Residential Construction; Inventory Management; Sustainable Construction; Federal Capital Territory (FCT)

INTRODUCTION

The construction industry plays a pivotal role in economic growth, infrastructure development, employment generation, and urban transformation. In developing economies such as Nigeria, increasing urbanization, rapid population growth, and rising demand for housing have accelerated residential construction activities, particularly in major urban centres. This expansion has increased the need for efficient construction resource management to ensure timely project delivery, cost control, and sustainable infrastructure development (Aigbavboa & Thwala, 2021). Among the critical resources required for successful project delivery, construction materials account for a substantial proportion of project costs, making effective logistics management indispensable for improving productivity and minimizing waste.

Construction logistics encompasses the planning, procurement, transportation, storage, handling, coordination, and distribution of construction materials, equipment, and information throughout the project lifecycle. Effective logistics systems ensure that construction materials are delivered to project sites in the right quantity, at the right time, and in the required condition while minimizing delays, operational inefficiencies, and unnecessary costs. Consequently, construction logistics optimization has become an essential component of modern construction management, with increasing emphasis on mechanisms such as transportation forecasting, delivery scheduling, inventory management, supplier coordination, site material control systems, and lean construction logistics practices to enhance project performance and resource utilization (Chen & Luo, 2021; Rahman, Salim & Kumar, 2023).

Despite advances in logistics management, construction material waste remains one of the most persistent challenges confronting the construction industry. Material losses resulting from poor handling, inefficient transportation, inadequate storage, over-ordering, theft, and weak inventory management contribute significantly to project cost overruns, schedule delays, reduced profitability, and environmental degradation. Beyond the economic implications, construction waste increases pressure on natural resources and contributes to environmental pollution through the generation of construction debris. Consequently, improving logistics efficiency has become increasingly important in achieving sustainable construction and resource-efficient project delivery (Wang & Zhang, 2022; Ebekozien & Aigbavboa, 2022).

Lean construction logistics has emerged as an effective approach for addressing these challenges by eliminating non-value-adding activities, improving workflow, and promoting efficient utilization of construction resources. Through practices such as Just-in-Time material delivery, supplier integration, continuous improvement, and optimized inventory management, lean logistics reduces material waste while improving productivity and overall project performance (Chidiobi, 2022). Similarly, transportation forecasting and delivery planning enable construction firms to anticipate material requirements, optimize delivery schedules, reduce transportation delays, and minimize logistics-related inefficiencies (Rahman, Salim & Kumar, 2023).

The Federal Capital Territory (FCT), Abuja, has experienced rapid urban expansion over the past decade, leading to increased residential housing development across districts such as Kubwa, Lugbe, Gwarinpa, Lokogoma, Apo, Dawaki, and Kuje. The growth in construction activities has significantly increased demand for construction materials and intensified logistics operations associated with procurement, transportation, storage, and site management (Adebayo & Oke, 2024). However, many construction firms continue to experience logistics-related challenges, including delayed material deliveries, poor inventory management, inadequate site material control, weak supplier coordination, and increasing material waste, all of which negatively affect project performance (Nwachukwu & Salihu, 2025).

Although previous studies have examined construction logistics management, material management practices, supply chain coordination, and project delivery performance, limited empirical attention has been given to the mechanisms of construction logistics optimization for residential construction materials within the Federal Capital Territory, Nigeria.

Existing studies have largely investigated individual aspects of logistics management without comprehensively integrating transportation forecasting, delivery management, inventory management, supplier coordination, site material control systems, and lean construction logistics within a unified analytical framework. Furthermore, empirical evidence on the effectiveness of these logistics optimization mechanisms in reducing material waste and improving operational efficiency in residential construction projects within the FCT remains limited. This knowledge gap highlights the need for further investigation to provide evidence-based recommendations for improving logistics performance and promoting sustainable construction practices.

Against this background, this study examines the mechanisms of construction logistics optimization for residential construction materials across the Federal Capital Territory, Nigeria. Specifically, the study identifies the logistics optimization mechanisms adopted by construction firms, examines the major factors contributing to construction material waste, evaluates the effectiveness of logistics optimization practices in reducing waste and improving operational efficiency, and assesses strategies for enhancing sustainable construction logistics.

The study focuses on residential construction projects within the Federal Capital Territory and draws data from construction professionals, including engineers, architects, quantity surveyors, builders, project managers, procurement officers, logistics coordinators, and contractors. The findings provide empirical evidence to support construction professionals, project managers, policymakers, and other stakeholders in improving logistics planning, reducing material waste, and advancing sustainable residential construction in Nigeria.

LITERATURE REVIEW

Construction logistics optimization has become a critical component of modern construction management because of its influence on project performance, resource utilization, cost control, and environmental sustainability. Effective construction logistics ensures the timely planning, procurement, transportation, storage, handling, and distribution of construction materials throughout the project lifecycle. As construction projects become increasingly complex, efficient logistics systems have become essential for coordinating multiple stakeholders, minimizing disruptions, and ensuring that materials are available at the required location, quantity, and quality to support uninterrupted project execution (Chen & Luo, 2021). Consequently, construction logistics is no longer viewed merely as an operational function but as a strategic process that directly influences productivity, competitiveness, and sustainable project delivery.

A growing body of literature demonstrates that construction logistics optimization contributes significantly to reducing project delays, improving operational efficiency, and minimizing construction waste. Rahman, Salim and Kumar (2023) reported that effective logistics planning improves coordination among contractors, suppliers, and project managers, resulting in more reliable material delivery and enhanced project performance. Similarly, Aigbavboa and Thwala (2021) observed that logistics optimization improves resource utilization and reduces avoidable project costs through better planning and coordination of material flows. Although these studies consistently recognize the importance of logistics optimization, they primarily evaluate its influence on overall project performance without comprehensively examining the individual contributions of transportation forecasting, delivery management, inventory management, supplier coordination, and site material control within residential construction projects.

Material waste continues to represent one of the most significant challenges confronting the global construction industry. Previous studies have identified poor material handling, inadequate storage facilities, transportation damage, over-ordering, theft, and inefficient inventory management as major sources of material losses during construction activities. Wang and Zhang (2022) argued that construction material waste substantially increases project costs, reduces productivity, and undermines environmental sustainability through unnecessary consumption of natural resources and increased waste disposal. Likewise, Ebekozien and Aigbavboa (2022) emphasized that effective waste reduction strategies not only improve economic performance but also contribute to sustainable construction practices. These findings collectively suggest that reducing material waste requires an integrated logistics management approach rather than isolated improvements in material handling or procurement practices.

Among the logistics optimization mechanisms reported in the literature, inventory management, supplier coordination, and site material control have received considerable attention. Effective inventory management minimizes stock shortages and excessive inventory while improving material availability and reducing storage costs (Akinradewo & Aigbavboa, 2022). Similarly, supplier coordination enhances communication between project participants, improves delivery reliability, and supports efficient procurement processes (Chen & Luo, 2021). Site material control systems further reduce losses by improving material monitoring, storage, security, and utilization throughout project execution (Aboginije et al., 2021). Although these mechanisms have been widely acknowledged individually, relatively few studies have investigated their combined influence on material waste reduction within a single analytical framework.

Lean Construction Theory provides an appropriate theoretical foundation for understanding construction logistics optimization. The theory, developed by Koskela (1992), emphasizes the elimination of non-value-adding activities, continuous improvement, and efficient utilization of resources throughout the construction process. Lean construction principles such as Just-in-Time material delivery, continuous workflow improvement, supplier integration, and waste elimination have increasingly been adopted to improve logistics efficiency and project performance (Chidiobi, 2022). These principles align closely with construction logistics optimization by promoting coordinated material flow, reducing unnecessary inventory, minimizing transportation inefficiencies, and enhancing operational effectiveness. Consequently, Lean Construction Theory provides a suitable framework for examining the relationships between logistics optimization mechanisms and material waste reduction.

Despite the increasing volume of research on construction logistics and material management, significant knowledge gaps remain. Existing studies have largely concentrated on general supply chain management, project delays, or isolated material management practices, with limited empirical attention given to the integrated effects of transportation forecasting, delivery management, inventory management, supplier coordination, site material control systems, and lean construction logistics on residential construction projects. Furthermore, empirical evidence from Nigeria, particularly within the Federal Capital Territory, remains scarce despite the rapid expansion of residential construction activities in the region. The absence of comprehensive evidence limits the development of context-specific strategies for improving logistics performance and promoting sustainable construction practices.

This study addresses these gaps by examining construction logistics optimization mechanisms within residential construction projects across the Federal Capital Territory, Nigeria. Unlike previous studies that considered individual logistics practices in isolation, this study evaluates the combined influence of multiple logistics optimization mechanisms on material waste reduction and operational efficiency using a mixed-method approach. The findings therefore contribute to the growing body of knowledge on construction logistics optimization while providing empirical evidence to support decision-making by construction professionals, policymakers, and other stakeholders seeking to improve sustainable residential construction in Nigeria.

METHODOLOGY

This study adopted a mixed-method research design to investigate the mechanisms of construction logistics optimization for residential construction materials across the Federal Capital Territory (FCT), Nigeria. The mixed-method approach was considered appropriate because it enabled the collection of both quantitative and qualitative data required to provide a comprehensive understanding of construction logistics practices, material management systems, waste generation factors, and optimization mechanisms within residential construction projects. Quantitative data were obtained through structured questionnaires administered to construction professionals, while qualitative insights were generated through Key Informant Interviews (KIIs) conducted with selected industry experts involved in construction logistics operations.

The study was conducted within the Federal Capital Territory (FCT), Abuja, Nigeria. The FCT was selected because it represents one of the fastest-growing urban centres in Nigeria and has experienced significant residential housing development driven by rapid urbanization, population growth, and increased real estate investments. The increasing volume of residential construction projects within districts such as Kubwa, Lugbe, Gwarinpa, Lokogoma, Apo, Dawaki, and Kuje has intensified the demand for construction materials and logistics services, making the area suitable for investigating construction logistics optimization mechanisms.

The target population comprised construction professionals actively involved in residential construction projects within the FCT. The population was drawn from the membership records of the Council for the Regulation of Engineering in Nigeria (COREN), the Nigerian Institute of Architects (NIA), the Nigerian Institute of Quantity Surveyors (NIQS), and the Nigerian Institute of Building (NIOB). These professionals were selected because of their direct involvement in project planning, procurement, logistics coordination, material management, and site supervision activities.

Table 1.0: Population of Construction Professionals in the Federal Capital Territory. (FCT)

S/N	**Professional Body**	**National Membership**	**Proportion Operating in FCT**	**Estimated Population in FCT**
1	Council for the Regulation of Engineering in Nigeria (COREN)	82,500	12%	9,900
2	Nigerian Institute of Architects (NIA)	18,200	10%	1,820
3	Nigerian Institute of Quantity Surveyors (NIQS)	9,000	12%	1,080

4	Nigerian Institute of Building (NIOB)	6,500	10%	650
Total		**116,200**		**13,450**

Source: COREN (2024); NIA (2024); NIQS (2024); NIOB (2024).

The sample size for the study was determined using Cochran's (1977) formula for large populations:

$$n_0 = \frac{Z^2pq}{e^2}$$

Where:

n_0= sample size

Z= standard normal variate at 95% confidence level (1.96)

p= estimated population proportion (0.5)

q= 1 − p (0.5)

e= margin of error (0.05)

Substituting the values into the formula yielded a sample size of 384 respondents. To account for possible non-response and incomplete questionnaires, the sample size was adjusted upward to 389 respondents. A proportionate stratified sampling technique was subsequently employed to ensure adequate representation of all professional categories within the study population. The sample allocation was determined using:

$$n_h = \frac{N_h}{N} \times n$$

Where:

n_h= sample size allocated to each stratum;

N_h= population of each stratum;

N= total population; and

n= total sample size.

The proportional distribution of the sample is presented in Table II.

Table 2:0 Proportionate Distribution of Sample Size.

Professional Category	**Population**	**Sample Size**
Engineers (COREN)	9,900	286

Architects (NIA)	1,820	53
Quantity Surveyors (NIQS)	1,080	31
Builders (NIOB)	650	19
Total	**13,450**	**389**

Source: Researcher's Computation (2025).

Primary and secondary sources of data were utilized for the study. Primary data were collected through the administration of structured questionnaires and Key Informant Interviews, while secondary data were obtained from journal articles, textbooks, conference proceedings, government reports, and other relevant publications relating to construction logistics optimization, material management, and waste reduction. The questionnaire was structured in two sections. Section A captured respondents' demographic characteristics, while Section B focused on transportation forecasting, delivery management, inventory management, supplier coordination, site material control systems, lean construction logistics, and waste management practices. Responses were measured using a five-point Likert scale as presented in Table 3.0.

Table 3.0: Likert Scale Measurement.

Response Category	Scale Value
Strongly Agree (SA)	5
Agree (A)	4
Undecided (U)	3
Disagree (D)	2
Strongly Disagree (SD)	1

Source: Researcher's Computation (2025).

The validity of the research instrument was established through face and content validation by experts in construction management and research methodology. Their observations and recommendations were incorporated into the final version of the questionnaire before administration. Reliability was assessed through a pilot study and evaluated using Cronbach's Alpha coefficient:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

Where:

α= Cronbach's Alpha coefficient;

k= number of questionnaire items;

σ_i^2= variance of individual items; and

σ_t^2= total variance.

Data collected were analysed using both descriptive and inferential statistical techniques. Descriptive statistics including frequencies, percentages, mean scores, and Relative Importance Index (RII) were used to analyse respondents' perceptions and rank the identified logistics optimization mechanisms, waste generation factors, and improvement strategies. The Relative Importance Index was computed as:

$$RII = \frac{\sum W}{A \times N}$$

Where:

W= total weight assigned by respondents;

A= highest possible weight (5); and

N= total number of respondents.

The RII values were used to rank variables according to their relative significance.

To determine the effect of construction logistics optimization mechanisms on waste reduction and operational efficiency, multiple regression analysis was employed. The model was specified as:

$$Y = \beta_0 + \beta_1 TF + \beta_2 DM + \beta_3 IM + \beta_4 SC + \beta_5 SMC + \beta_6 LCL + \varepsilon$$

Where:

Y= Waste Reduction and Operational Efficiency Outcome;

TF= Transportation Forecasting;

DM= Delivery Management;

IM= Inventory Management;

SC= Supplier Coordination;

SMC= Site Material Control Systems;

LCL= Lean Construction Logistics;

β_0= Constant Term;

$\beta_1 - \beta_6$= Regression Coefficients; and

ε= Error Term.

Qualitative data obtained through the Key Informant Interviews were analysed using thematic analysis. The interview responses were transcribed, coded, categorized into themes, and integrated with the quantitative findings to provide a deeper understanding of construction logistics optimization mechanisms and their implications for residential construction material management within the Federal Capital Territory, Nigeria.

4. RESULTS AND DISCUSSION

The findings reveal that construction firms operating within the Federal Capital Territory (FCT) have adopted several construction logistics optimization mechanisms aimed at improving material management efficiency and reducing waste generation on residential construction sites. The analysis shows that Site Material Control Systems emerged as the most widely adopted logistics optimization mechanism with a mean score of 4.62 and a Relative Importance Index (RII) of 0.924, followed by Supplier Coordination Mechanisms (Mean = 4.55; RII = 0.910) and Inventory Management Systems (Mean = 4.48; RII = 0.896). Delivery Scheduling Systems, Material Handling Procedures, Lean Construction Logistics Practices, Transportation Forecasting Systems, and Route Planning and Optimization Systems were also highly rated by respondents, indicating widespread adoption of logistics optimization practices within residential construction projects in the FCT. The overall grand mean of 4.39 and grand RII of 0.879 suggest a high level of implementation of logistics optimization mechanisms among construction firms. These findings indicate increasing recognition of efficient material control, supplier integration, inventory monitoring, and delivery planning as critical drivers of project performance and operational efficiency. The findings support Lean Construction Theory and Supply Chain Management Theory, which emphasize efficient resource flow, stakeholder coordination, and waste minimization as essential elements of successful construction project delivery.

Table 4.0: Logistics Optimization Mechanisms in Residential Construction.

S/N	Mechanism	Mean Score	RII	Rank
1	Site Material Control Systems	4.62	0.924	1st
2	Supplier Coordination Mechanisms	4.55	0.910	2nd

3	Inventory Management Systems	4.48	0.896	3rd
4	Delivery Scheduling Systems	4.42	0.884	4th
5	Material Handling Procedures	4.38	0.876	5th
6	Lean Construction Logistics Practices	4.30	0.860	6th
7	Transportation Forecasting Systems	4.24	0.848	7th
8	Route Planning and Optimization Systems	4.16	0.832	8th
Grand Mean		**4.39**	**0.879**	

Source: Field Survey, 2025.

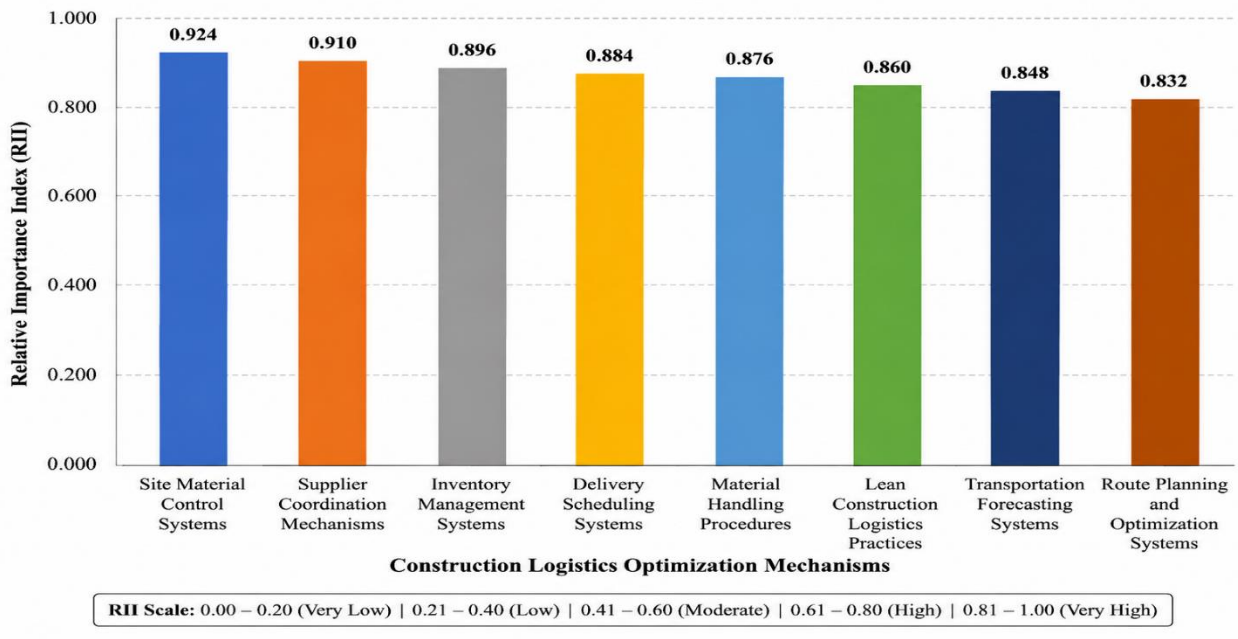

Figure 1.0: Relative Importance Index of Construction Logistics Optimization Mechanisms.

The study further identified the major factors contributing to material waste generation on residential construction sites. The results indicate that Poor Material Handling was the most significant factor contributing to waste generation, recording a mean score of 4.71 and an RII value of 0.942. Material Damage During Transportation (Mean = 4.65; RII = 0.930) and Inadequate Storage Facilities (Mean = 4.58; RII = 0.916) ranked second and third, respectively. Other significant contributors included Over-ordering of Materials, Poor Site Coordination, Poor Inventory Management, Weather Exposure, and Theft and Vandalism. The grand mean of 4.46 and grand RII of 0.891 indicate strong consensus among respondents that deficiencies in handling, transportation, storage, and inventory systems remain major causes of construction material waste within residential projects. These findings reinforce previous studies that identified poor handling practices, transportation damage, inadequate storage, and weak inventory systems as major causes of material losses within construction projects.

Table 5.0: Factors Contributing to Material Waste Generation.

S/N	Factor	Mean Score	RII	Rank
1	Poor Material Handling	4.71	0.942	1st
2	Material Damage During Transportation	4.65	0.930	2nd
3	Inadequate Storage Facilities	4.58	0.916	3rd
4	Over-ordering of Materials	4.49	0.898	4th
5	Poor Site Coordination	4.42	0.884	5th
6	Poor Inventory Management	4.35	0.870	6th
7	Weather Exposure	4.28	0.856	7th
8	Theft and Vandalism	4.16	0.832	8th
Grand Mean		**4.46**	**0.891**	

Source: Field Survey, 2025.

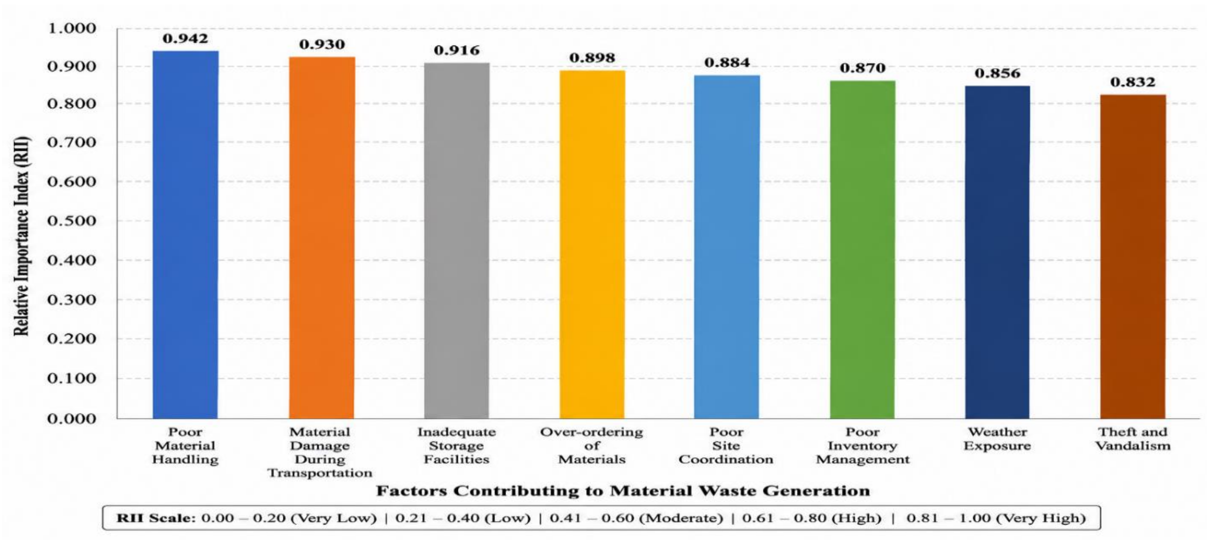

Figure 2.0: Major Factors Contributing to Material Waste Generation.

The effectiveness of construction logistics optimization mechanisms in reducing material waste and operational inefficiencies was also assessed. The findings show that Site Material Control was perceived as the most effective mechanism, with a mean score of 4.68 and an RII value of 0.936. Supplier Coordination (Mean = 4.60; RII = 0.920) and Inventory Management (Mean = 4.53; RII = 0.906) also recorded high ratings. The overall grand mean of 4.44 and grand RII of 0.888 indicate strong agreement among respondents regarding the effectiveness of logistics optimization practices. The findings suggest that effective logistics planning, inventory control, supplier integration, and material monitoring substantially improve resource utilization and reduce avoidable material losses. These findings are consistent with Lean Construction Theory, which advocates waste elimination through efficient planning and continuous process improvement.

Table 6.0: Effectiveness of Construction Logistics Optimization Mechanisms

S/N	**Mechanism**	**Mean Score**	**RII**	**Rank**
1	Site Material Control Reduces Material Losses	4.68	0.936	1st
2	Supplier Coordination Improves Material Availability	4.60	0.920	2nd
3	Inventory Management Reduces Overstocking and Shortages	4.53	0.906	3rd
4	Delivery Scheduling Improves Workflow Efficiency	4.47	0.894	4th
5	Transportation Forecasting Reduces Delivery Delays	4.39	0.878	5th
6	Lean Construction Logistics Minimizes Material Waste	4.34	0.868	6th
7	Route Planning Reduces Transportation Waste	4.28	0.856	7th
8	Logistics Optimization Improves Overall Project Performance	4.22	0.844	8th
Grand Mean		**4.44**	**0.888**	

Source: Field Survey, 2025.

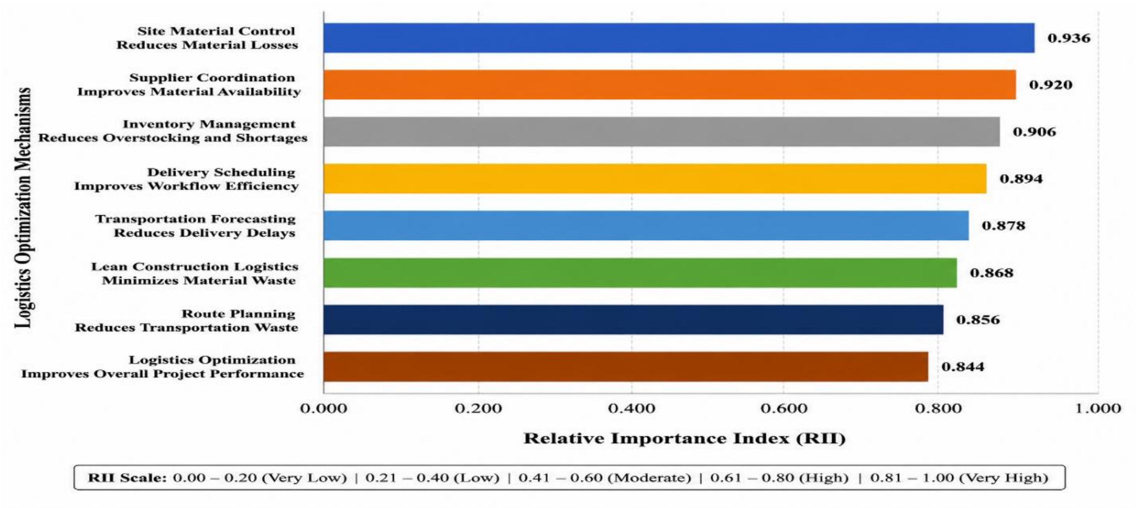

Figure 3.0: Effectiveness of Construction Logistics Optimization Mechanisms.

The findings further reveal practical strategies required to improve construction logistics optimization and sustainable waste management within residential construction projects. Respondents ranked Adoption of Digital Logistics Management Systems as the most effective strategy (Mean = 4.73; RII = 0.946), followed by Strengthening Site Material Control Systems (Mean = 4.66; RII = 0.932) and Training on Lean Construction Logistics Practices (Mean = 4.61; RII = 0.922). Other important strategies include Improved Supplier Coordination Mechanisms, Integration of Transportation Forecasting Systems, Computerized Inventory Management Systems, Enforcement of Sustainable Waste Management Policies, and Regular Monitoring of Logistics Performance. The grand mean of 4.52 and grand RII of 0.904 indicate strong agreement regarding the effectiveness of these improvement measures. The findings suggest that digitalization, improved material control systems, training, and enhanced stakeholder coordination can substantially improve logistics efficiency and reduce material waste on construction sites.

Table 7.0: Strategies for Improving Construction Logistics Optimization

S/N	Improvement Strategy	Mean Score	RII	Rank
1	Adoption of Digital Logistics Management Systems	4.73	0.946	1st
2	Strengthening Site Material Control Systems	4.66	0.932	2nd
3	Training on Lean Construction Logistics Practices	4.61	0.922	3rd
4	Improved Supplier Coordination Mechanisms	4.55	0.910	4th
5	Integration of Transportation Forecasting Systems	4.49	0.898	5th
6	Computerized Inventory Management Systems	4.43	0.886	6th

7	Enforcement of Sustainable Waste Management Policies	4.37	0.874	7th
8	Regular Monitoring of Logistics Performance	4.31	0.862	8th
Grand Mean		**4.52**	**0.904**	

Source: Field Survey, 2025.

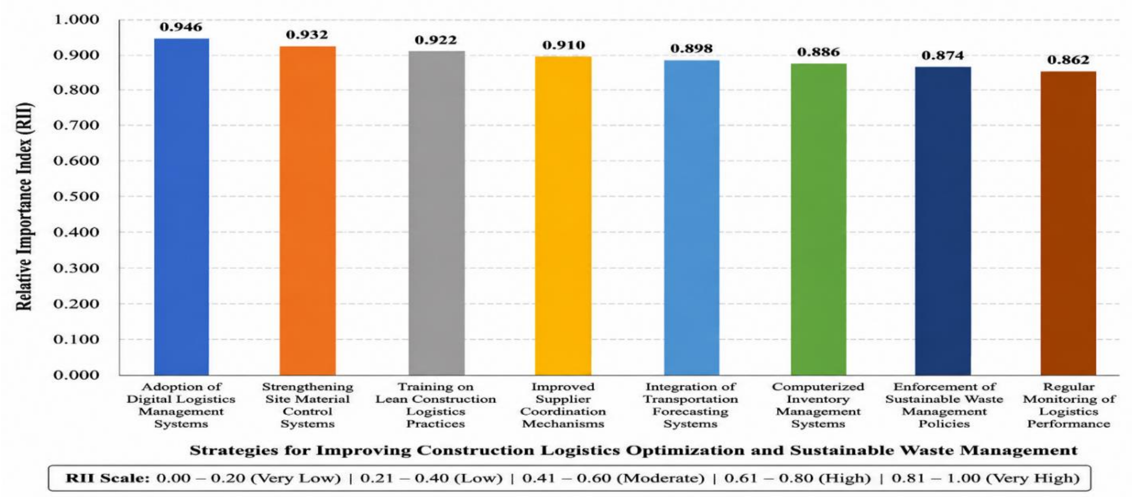

Figure 4.0: Strategies for Improving Construction Logistics Optimization and Sustainable Waste Management.

The regression analysis further established that construction logistics optimization mechanisms significantly influence material waste reduction on residential construction sites. The model summary indicates a strong relationship between the predictor variables and material waste reduction ($R = 0.812$), while the coefficient of determination ($R^2 = 0.659$) shows that approximately 65.9% of the variation in material waste reduction is explained by the logistics optimization variables included in the model. The ANOVA result revealed that the overall regression model is statistically significant ($F = 134.102$; $p = 0.000$), leading to the rejection of the null hypothesis that construction logistics optimization mechanisms have no significant effect on material waste reduction. The regression coefficients further indicate that Site Material Control ($\beta = 0.352$; $p < 0.001$), Supplier Coordination ($\beta = 0.294$; $p < 0.001$), Inventory Management ($\beta = 0.236$; $p < 0.001$), Delivery Scheduling ($\beta = 0.189$; $p < 0.001$), and Transportation Forecasting ($\beta = 0.161$; $p = 0.001$) all exert significant positive effects on material waste reduction. These findings demonstrate that strengthening logistics coordination systems can substantially reduce material waste and improve operational efficiency within residential construction projects.

Table 8.0: Effects of Logistics Optimization on Material Waste Reduction.

Variable	B	Beta	t-value	p-value
Constant	0.814	–	3.858	0.000
Site Material Control	0.324	0.352	6.894	0.000
Supplier Coordination	0.281	0.294	5.510	0.000
Inventory Management	0.219	0.236	4.469	0.000
Delivery Scheduling	0.173	0.189	3.932	0.000
Transportation Forecasting	0.148	0.161	3.524	0.001

Model Statistics: $R = 0.812$; $R^2 = 0.659$; Adjusted $R^2 = 0.651$; $F = 134.102$; $p = 0.000$.

Source: Field Survey, 2025

5.0 CONCLUSION AND RECOMMENDATIONS

The findings of this study demonstrate that construction logistics optimization plays a critical role in improving material management and enhancing operational efficiency in residential construction projects within the Federal Capital Territory (FCT), Nigeria. The study established that construction firms have adopted various logistics optimization mechanisms, with Site Material Control Systems, Supplier Coordination Mechanisms, and Inventory Management Systems emerging as the most widely implemented practices. These mechanisms facilitate efficient material flow, improve coordination among project stakeholders, and contribute to enhanced project performance.

The study further identified Poor Material Handling, Material Damage During Transportation, and Inadequate Storage Facilities as the leading causes of construction material waste. These findings underscore the need for improved logistics planning, better handling procedures, and effective inventory management to minimize material losses and enhance resource utilization. The results also revealed that the adoption of Digital Logistics Management Systems, strengthened Site Material Control Systems, and Lean Construction Logistics practices constitute the most effective strategies for improving construction logistics performance and promoting sustainable waste management within residential construction projects.

Furthermore, the regression analysis confirmed that construction logistics optimization mechanisms have a statistically significant positive influence on material waste reduction. The model explained approximately 65.9% of the variation in material waste reduction, indicating that improvements in logistics planning, supplier coordination, inventory management, delivery scheduling, and site material control can substantially enhance construction efficiency while reducing material losses. These findings provide empirical evidence that effective logistics management is indispensable for achieving cost-effective, resource-efficient, and environmentally sustainable residential construction.

Based on these findings, the study recommends that construction firms should strengthen site material control systems and adopt integrated digital logistics management technologies to improve inventory monitoring, material tracking, and delivery scheduling. Construction organizations should also promote stronger collaboration with suppliers through coordinated procurement and communication systems to ensure timely material delivery and minimize supply chain disruptions. In addition, regular capacity-building programmes should be organized to equip construction professionals with practical skills in lean construction logistics, material handling, and sustainable waste management. Regulatory agencies and professional bodies should develop and enforce industry guidelines that encourage the adoption of modern logistics optimization practices and digital technologies across residential construction projects. Finally, future studies should extend this research to other regions of Nigeria and examine additional technological and organizational factors that influence construction logistics performance and sustainable project delivery.

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