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Life cycle assessment and supply chain visibility in Nigeria Maritime University, South-South Nigeria

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Abstract - Limited knowledge and awareness on green procurement policies among procurement officers, end users, and suppliers constitute obstacles to its effective implementation. The study investigates the relationship between product life cycle monitoring and real- time data sharing in Nigerian Maritime University. The total population of the study comprised of 1,252 employees, and sample size was determined using taro Yamane formula and calculated as 303. The study employed a descriptive survey research design, and a stratified random sampling technique in the distribution of the survey to ensure optimum allocation of survey to each stratum. The study population includes: procurement officers, internal auditors, logistics managers, administrative staff, and heads of departments. Out of 303 questionnaires distributed only 281 were returned and utilized while the remaining 22 were not returned and utilized for the study. Statistical tools such as descriptive, inferential statistics, and linear regression were used to analyse the hypotheses at 5 % significant level. The findings showed that the combined use of life cycle assessment and real-time visibility has a significant impact on better organizational and environmental performance. The study recommend that university management should organize regular training programmes to improve skill development of lecturers, researchers, technical staff, and students on LCA software (e.g., SimaPro, OpenLCA, GaBi) and real-time visibility technologies.

Keywords: lifecycle assessment, supply chain visibility, institutional theory, and real-time data sharing

1. Introduction

Nowadays, Life Cycle Assessment (LCA) is one of the most efficient tools for environment management to evaluate the environmental impacts of products, services and organizational activities throughout their whole life cycle; from raw material acquisition, production, transportation and use up to disposal or recycling (Isah et al., 2025; Deda et al., 2023). This methodology enables organizations to identify environmental hot spots, increase resource efficiency, reduce waste, reduce carbon footprint and make evidence-based sustainability decisions. However, the application of LCA in Nigeria is at its infancy despite the growing awareness of the need for sustainable development practices and environmental stewardship.

Once again, the successful execution of procurement practices depends fundamentally on strong institutional commitment, enabling policy frameworks and adequate stakeholder awareness. However, there is limited institutional support towards the implementation of green procurement initiatives in Nigerian Maritime University. The lack of comprehensive green procurement policies, insufficient management commitment, inadequate staff training programmes and the absence of incentive mechanisms for sustainable purchasing significantly constrains the integration of environmental sustainability considerations into procurement decision-making processes.

Furthermore, a lack of knowledge and awareness about green procurement principles among procurement officers, end users and suppliers is a major obstacle to effective implementation. This gap of knowledge promotes resistance to organizational change, jeopardizes stakeholder engagement and diminishes the effectiveness of sustainability-driven procurement initiatives. Thus, the weak institutional framework and low environmental consciousness among the key stakeholders is still a barrier to the successful adoption and institutionalization of green procurement practices within the University. problems necessitate study which aims at investigating the relationship between product life cycle monitoring and real- time data sharing in Nigerian Maritime University.

Additionally, the higher education sector in Nigeria is expected to incorporate sustainability principles into its operations, procurement and logistics. Universities use large quantities of energy, water, office supplies, laboratory equipment, transportation services and construction materials and therefore have an important role in environmental impacts. Thus, the use of Life Cycle Assessment in universities offers opportunities to assess the environmental impacts of procurement decisions, campus operations, waste management systems and infrastructure development (Deda et al., 2023; Isah et al., 2025). Besides protecting the environment, LCA also helps university management to promote sustainable procurement, improve operational efficiency, reduce costs, and support institutional compliance with national and international sustainability frameworks. Recent empirical evidence suggests that universities adopting LCA are better able to improve their environmental performance and their organisational sustainability reporting and resource optimization. Previous empirical studies have predominantly concentrated on the manufacturing, logistics, and production sectors, with limited attention devoted to the higher education sector, particularly maritime universities. Looking at the underexplored context, the study focuses on the application of Life Cycle Assessment (LCA) and supply chain visibility within Nigerian maritime universities to address a significant gap in the existing body of knowledge.

Supply Chain Visibility (SCV) refers to the ability of organisations to have access to accurate, timely and comprehensive information regarding the flow of materials, products, information and financial resources across the supply chain (Sunmola & Apeji, 2024). This includes real-time data sharing, inventory monitoring, procurement transparency, logistics tracking and information provision for all stakeholders in a supply chain from end to end. By having better visibility into the supply chain, organisations can make better forecasts, improve their decision making, reduce operational risks, improve collaboration with suppliers, and improve the delivery of services (Junaid et al., 2024; Sunmola & Apeji, 2024; Yu et al., 2024).

Previous studies have revealed a connection between supply chain visibility and life cycle assessment across various industries and globally. The study conducted by Sunmola and Apeji (2024) on manufacturing firms in Nigeria showed that information sharing, supply chain relationships, internal linkages, green absorptive capacity and supply chain visibility are positively correlated. The findings stress the importance of collaborative networks and effective information exchange in improving supply chain visibility and overall supply chain performance. Another study by Nubi et al. (2022) using Nigerian cities performed life-cycle sustainability assessment (LCSA) of waste-to-energy systems. The results showed that Waste-to-Energy (WtE) technologies contribute significantly to environmental, economic and social sustainability in both Lagos and Abuja with Lagos having slightly better sustainability benefits.

Although previous studies have provided useful insights on the sustainability outcomes of Waste-to-Energy technologies, none has specifically examined the effect of Life Cycle Assessment (LCA) on supply chain visibility within Nigeria Maritime University, South-South Nigeria. Hence, there is a considerable empirical and contextual gap in the literature. This research is intended to close this gap. The study objective focuses on exploring the application of product life cycle monitoring in improving supply chain visibility in Nigerian Maritime University. This study is motivated to contribute to the expanding literature on sustainable supply chain management in Nigerian higher education institutions.

On the other hand, Hauschild et al. (2024) defined life cycle assessment (LCA) as a systematic analytical methodology for evaluating the environmental impacts associated with a product, process or service throughout its life cycle, from raw material extraction, through manufacturing, transportation, use, to disposal or recycling. The authors highlight further that LCA helps organisations identify environmental hotspots, optimism resource use, reduce greenhouse gas emissions, and support sustainable decision-making. LCA is a globally accepted one of the most extensive tools for evaluating environmental sustainability and enhancing organisational performance (International Organization for Standardization, ISO, 2006) under the ISO 14040 and ISO 14044 standards.

Furthermore, supply chain visibility is the ability of organizations to access, monitor and share accurate, timely and relevant information on the movement of materials, products, inventory, finances and information at every stage of the supply chain. Increased supply chain visibility allows organisations to make better decisions, reduce operational risks, and improve supplier collaboration, increase customer satisfaction, and increase supply chain resilience (Junaid et al., 2024). Similarly, Yu et al. (2024) defined supply chain visibility as the extent to which supply chain partners have access to information about real-time operations" which "enhances coordination, transparency and collaborative decision-making across the supply chain network. Additionally, Sunmola and Apeji (2024) define supply chain visibility as the ability of an organization to obtain accurate and timely information within its own operations and with its external supply chain partners, hence enabling efficient information sharing, transparency and end-to-end supply chain management.

On the other hand, Sassanelli et al. (2023) defined product life cycle monitoring as the continuous monitoring, measurement and evaluation of the environmental, operational and sustainability performance of a product at all stages of its life cycle, from the extraction of raw materials, to manufacturing, distribution, use, maintenance and the disposal or recycling at the end of its life cycle. The aim is to detect inefficiencies, monitor environmental impacts, optimise resources utilisation and support continuous improvement programs. Furthermore, Sassanelli et al. (2023) defined product life cycle monitoring as the ongoing collection and examination of information related to a product throughout its entire life cycle, with the goal of improving environmental sustainability, operational efficiency, and circular economy performance.

Alternatively, real-time data sharing refers to the ongoing sharing of operational data among supply chain participants, enabling prompt decision-making, improved coordination, and enhanced organisational responsiveness (Yu et al., 2024). Similarly, Junaid et al. (2024) describe real-time data sharing as the instantaneous sharing and availability of correct information in interconnected supply chain systems, enabling organizations to enhance visibility, traceability, sustainability, and supply chain resilience.

Life cycle assessment (LCA) has become a fundamental framework for evaluating sustainability across supply chains by measuring environmental impacts while increasingly incorporating economic, social, and strategic dimensions. Research consistently shows that LCA supports resource optimization, identifies environmental hotspots, strengthens sustainable production planning, and facilitates the transition toward circular supply chains through recycling, remanufacturing, and waste reduction. More recent studies also integrate Social Life Cycle Assessment (S-LCA), emphasizing that sustainability extends beyond environmental performance to include labor conditions, stakeholder welfare, and community impacts.

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However, many investigations remain primarily focused on environmental indicators, while the integration of social, governance, and economic dimensions remains limited. Furthermore, the implementation of LCA is often constrained by inadequate data quality, methodological complexity, and insufficient digital infrastructure, particularly in developing countries (Mota et al., 2019; Herrera Almanza & Corona, 2020; Vidergar et al., 2021; Sultan et al., 2021; Yadav et al., 2024; Kurrahman et al., 2025).

Life cycle assessment (LCA) has become a fundamental approach for evaluating environmental impacts across supply chains by considering resource consumption, emissions, and waste generation throughout the entire product life cycle. Recent studies emphasize that integrating LCA into supply chain decision-making enables organizations to optimize production, sourcing, transportation, and distribution while simultaneously improving environmental performance and operational efficiency. The integration of LCA with supply chain optimization also supports more informed strategic planning and sustainability-oriented decision-making (Hülagü et al., 2025; Blass & Corbett, 2018; Kleinekorte et al., 2020).

A major research stream focuses on the application of LCA within food supply chains. These studies investigate environmental impacts from agricultural production through processing, distribution, consumption, and waste management. Researchers have highlighted the complexity of food systems due to multiple stakeholders, regional differences, and diverse production methods while proposing standardized assessment tools to improve environmental evaluation. Comparative analyses have also demonstrated differences in sustainability performance between conventional and organic production systems and identified methodological challenges in food supply chain assessment (Vidergar et al., 2021; Da Costa et al., 2022; Zira et al., 2021; Djekic et al., 2019).

Another important theme concerns the integration of digital technologies with life cycle assessment. Blockchain technology has emerged as a promising solution for improving data transparency, traceability, and reliability throughout supply chains. By enabling secure and real-time environmental data sharing among supply chain participants, blockchain enhances the accuracy of life cycle inventories and facilitates more effective sustainability monitoring and reporting (Zhang et al., 2020; Lin et al., 2021).

Several studies extend LCA applications to industrial production and manufacturing systems. Research has explored the environmental implications of additive manufacturing, chemical process design, and product platform management, demonstrating that LCA can simultaneously support cost reduction, process optimization, and environmental improvement. These approaches enable organizations to evaluate multiple production alternatives while balancing economic and sustainability objectives (Manco et al., 2023; Kleinekorte et al., 2020; Helo et al., 2024).

Strategic management and business planning represent another significant area of development. Researchers argue that integrating life cycle inventory and life cycle impact assessment into supply chain design enables firms to formulate sustainability-oriented business strategies. In parallel, life cycle thinking has increasingly been combined with carbon accounting frameworks to improve environmental performance measurement, regulatory compliance, and corporate sustainability reporting across global supply chains (Mota et al., 2019; Truant et al., 2024).

Sector-specific applications further demonstrate the flexibility of LCA across different industries. Studies have assessed environmental impacts in liquefied natural gas (LNG), sugarcane production, and metal and mineral supply chains, revealing that industry-specific inventories and emission accounting methods provide more accurate sustainability assessments. These analyses also contribute valuable datasets for improving future environmental modeling and supporting sector-specific policy development (Roman-White et al., 2021; Rodrigues & Machado, 2023; Lai et al., 2026).

Within the broader context of sustainable supply chain management, empirical studies highlight that organizational sustainability depends not only on environmental assessment but also on supply chain visibility, stakeholder collaboration, institutional support, and technological readiness. Research on Nigerian industries demonstrates persistent challenges including weak logistics systems, fragmented information sharing, procurement inefficiencies, inadequate infrastructure, and limited adoption of green supply chain practices across manufacturing, healthcare, construction, and maritime sectors. While studies acknowledge that green supply chain management improves operational efficiency, competitiveness, and sustainability performance, much of the existing literature remains conceptual or relies on cross-sectional survey designs, limiting evidence of long-term organizational transformation.

Likewise, investigations into supply chain visibility emphasize that transparency is essential for sustainable decision-making, yet implementation continues to be hindered by poor digital integration and organizational resistance to information sharing. Reviews of LCA applications in Nigeria further indicate that empirical research remains relatively scarce and concentrated within specific industries, revealing a substantial need for broader sectoral coverage and stronger policy-oriented analyses. Consequently, future research should develop integrated frameworks that combine life cycle assessment, circular supply chain principles, supply chain visibility, and green supply chain management while simultaneously considering environmental, economic, social, technological, and governance dimensions through longitudinal and interdisciplinary approaches. Such comprehensive models would provide stronger evidence for sustainable supply chain transformation and improve the practical implementation of sustainability strategies in developing economies (Olutuase et al., 2022; Orji et al., 2021; Okafor et al., 2021; Messina et al., 2022; Nsikan et al., 2023; Egunlae, 2024; Christian, 2025; Isah et al., 2025; Unegbu et al., 2025; Toyin & Moses, 2025; Sunmola & Apeji, 2026; Nnenanya & Igwe, 2026).

Conversely, this study is anchored on institutional theory initially developed by Meyer and Rowan (1977) and later advanced by DiMaggio and Powell (1983). Institutional Theory provides an explanation of why organizations implement structures, policies and practices not only to improve efficiency but also to gain legitimacy, credibility and social acceptance in their institutional environments. The theory assumes that firms seek legitimacy from governments, customers, professional bodies, accreditation agencies, investors, and society, rather than simply economic efficiency. Industries that follow accepted institutional norms are more likely to gain trust, reputation, and long-term survival (Scott, 2022).

Again, institutional Theory is relevant to study on lifecycle assessment and supply chain visibility in tertiary education because universities operate within complex institutional environments shaped by government regulations, accreditation standards, professional norms, societal expectations, and international sustainability guidelines. Universities are required to continuously adapt their governance structures, procurement policies, research agendas, quality assurance processes, and environmental management practices to maintain legitimacy with regulators, funding bodies, employers, students, and society (Scott, 2022).

For specialized institutions like the Nigeria Maritime University, the theory provides a robust framework for explaining the adoption of Life Cycle Assessment and supply chain visibility practices. Institutional pressures by the Federal Ministry of Education, the National Universities Commission (NUC), environmental regulatory agencies, professional maritime organisations and sustainable procurement policies can motivate the university to implement environmentally responsible procurement systems, improve real time information sharing and strengthen supply chain visibility. Therefore, Institutional Theory provides a useful theoretical ground for studying the impact of external institutional pressures on the adoption of Life Cycle Assessment practices and their impact on supply chain visibility in tertiary education institutions.

In the same way, Sunmola and Apeji, (2024) evaluated modelling supply chain visibility using a framework with considerations for manufacturing and business in Nigeria. The present study utilized a survey-based research methodology for data collection. A sampling strategy was used to administer survey to participants from different industry sectors, with an emphasis on manufacturing and business firms. In total, 204 useable questionnaires were obtained. A factor analysis was conducted to determine underlying factors in the data. The outcomes of this

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research, notably the strong positive relationships between information sharing, supply chain relationship, internal linkage, and green absorptive capacity, provide support for the argument that these factors are the major drivers of supply chain visibility. The analysis also found that external linkages with supply chain partners further enhance information sharing in the chain.

Similarly, Anucha (2023) investigated the relationship between green shipping practices and the environmental performance of maritime companies in South-South Nigeria. A cross-sectional survey research design was used with a population comprising 200 managers involved in the implementation of green shipping strategies across the region. The study employed a census sampling technique to ensure complete coverage of the target population. A structured questionnaire was used to collect primary data which was subjected to both face and content validity assessments to ascertain its suitability for the study objectives. The findings revealed a statistically significant positive relationship between the adoption of green shipping practices and environmental performance among maritime companies.

Conversely, previous studies by Sunmola and Apeji, (2024) utilized manufacturing and business sector in Nigeria; while Anucha (2023) focused on maritime companies in South-South Nigeria. Despite the valuable insights provided by prior studies, none examined the education sector. Therefore, this study contributes to the existing body of knowledge by evaluating how product life cycle monitoring improve supply chain visibility in Nigerian Maritime University. By addressing this contextual and geographical gap, the researchers contribute to the body of knowledge to fill these gaps.

2. Method

This study adopts a descriptive survey research design. The population of this study comprises staff of Nigeria Maritime University, particularly those involved in procurement and supply chain functions. This includes-procurement officers, internal auditors, logistics managers, administrative staff, and heads of departments. The study employed a stratified sampling technique to select individuals or participants who possess relevant professional expertise and experience in procurement department. The stratified random sampling technique was used to ensure that the sample adequately represented all relevant subgroups within the population.

The total population of 1,252 was determined using Taro Yamane's formula (1967) for finite population studies, with a 95% confidence level and a 5% margin of error. This approach ensured that data were collected from knowledgeable and relevant stakeholders, thereby improving the quality and applicability of the findings.

The study's population of procurement professionals was chosen from whom the respondents using the Yamane in 1967. The formula is stated as follows:

$$n = \frac{N}{1+Ne^2}$$

Where n → the required sample size
N = the Target Population
e = accuracy level required standard error = 5%
Where; N = 1,252; e = 0.05 (margin of error);
n= 1,252/ (1+ 1,252 $(0.05)^2$ n = 303.147
Thus, the **sample size = 303 employees**.

Moreover, the instruments were reviewed by two academic experts in supply chain and public procurement. Each instrument comprised of positive and negative statement related to green supplier selection and flexible sourcing. A pilot study involving 10 respondents were used to pre-test the instrument to measure the reliability. Primary data were analyzed using Pearson correlation at a 5% level of significance ($p < 0.05$) to determine statistical significance.

3. Results and Discussion

3.1 Results

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Primary data were gathered, systematically organized, and analyzed using the Statistical Package for Social Sciences (SPSS, Version 25). Out of the 303 questionnaires distributed, 282 were duly completed and returned, representing a high response rate, while 21 unreturned questionnaires were excluded from further analysis. The demographic profile of the respondents are stated below.

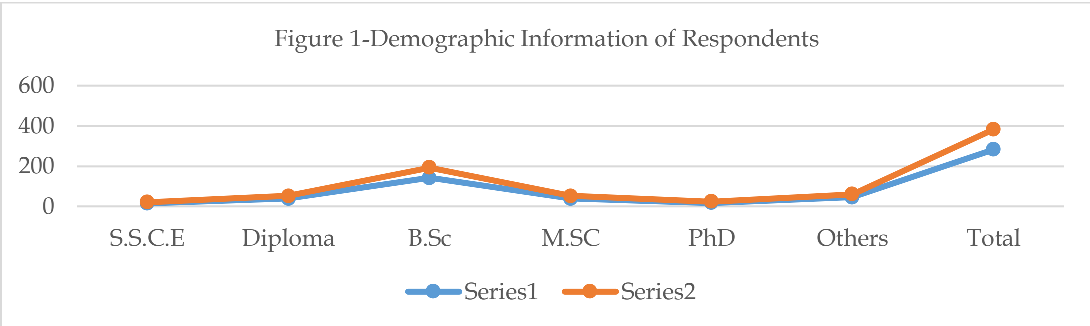
Table 1: Demographic Information of the Respondents

Education	Frequency	Percentage
S.S.C.E	15	5.32
Diploma	39	13.83
B.Sc	141	51.16
M.SC	39	13.83
PhD	18	6.38
Others	45	15.96
Total	282	100

Source: (Field Survey 2026)

The educational background of the participants varied, indicating that more than half of the participants possessed a BSc qualification (51.16%), followed by MSc and Diploma holders (13.83% each) respectively. The educational profile indicates a highly qualified sample, predominantly at the undergraduate level, with a notable proportion of postgraduate participants.

Analysis of respondents' qualifications shows a significant concentration in BSc holders, supplemented by diverse postgraduate and other qualifications. Figure 1 provides demographic information on educational background of the participants.



Source: (Field Survey, 2026)

3.1.1 Analysis of Research Question

To what extend does product life cycle monitoring affect real- time data sharing in Nigerian Maritime University.

Table 2: Investigative Questions on lifecycle assessment and real-time data sharing or visibility

S/N	Questions	SA	AG	UN	DA	SD	Total
A.	**Product Lifecycle Assessment (Independent Variable)**						
1	Inadequate data management systems reduce the effectiveness of LCA in enhancing institutional transparency.	139	127	5	11	0	282
2	Eco-friendly assessment enhances the transparency of	134	136	5	1	6	282

	environmental performance data across departments.						
3	Most times, the absence of reliable environmental databases weakens the accuracy of institutional analyses.	137	132	3	3	7	282
4	Sustainable assessment help institutions improve energy efficiency and waste management practices.	138	133	1	6	4	282
5	Institutional resistance to change limits the adoption of ecological evaluation in procurement and infrastructure development.	139	132	5	3	3	282
6	Lifecycle data analysis enables institutions to monitor and share sustainability metrics more effectively.	143	132	4	2	1	282
7	Integrating ecological practices into institutional planning supports long-term sustainability strategies.	138	141	2	1	0	282
B.	**Real-Time Data Sharing or Visibility (Dependent Variable)**						
1	Privacy concerns hinder open sharing of assessment data.	136	139	3	0	4	282
2	Lack of standardized digital tools weakens the link between ecological outcomes and operational visibility.	138	136	1	6	1	282
3	Limited technological infrastructure hinders real-time data sharing in lifecycle assessment processes.	132	143	5	1	1	282
4	Real-time data sharing strengthens decision-making accuracy in lifecycle-based procurement management.	139	125	10	6	2	282
5	The complexity of lifecycle data often leads to delays in real-time information sharing.	128	139	9	5	1	282
6	Data privacy concerns restrict the open sharing of lifecycle assessment results within tertiary institutions.	132	135	8	3	4	282
7	Lifecycle assessment enhances real-time data visibility in procurement.	131	139	2	7	3	282

Source: (Field Survey, 2025)

3.1.2 Decision Rule

The null hypothesis was rejected when the p-value was found to be less than 0.05; otherwise, the alternative hypothesis (HA) was accepted. The result of simple regression in table 4.8 below indicates that the null hypothesis stating that lifecycle assessment does not influence real-time data sharing or visibility in the Nigerian Maritime sector was rejected since the p-value (0.000) was below the critical threshold of 0.05. Conversely, the alternative hypothesis asserting that lifecycle assessment influences real-time data sharing or visibility in the Nigerian Maritime sector

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in the Nigerian Maritime sector was accepted. The test result indicates that there exists a significant relationship between independent and dependent variables.

3.1.3 Test of Research Hypotheses

H_{O3}: Lifecycle assessment does not influence real-time data sharing or visibility in the Nigeria Maritime University, South-South Region.

Table 3. Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.996[a]	.992	.992	5.88791	1.991

Source: (SPSS Version 25)
a. Predictors: (Constant), LCA
b. Dependent Variable: RTV.

Table 4: Analysis of Variance (ANOVA[a])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	144022.373	1	144022.373	4154.392	.000[b]
	Residual	1144.027	281	34.667		
	Total	145166.400	282			

Source: (SPSS Version 25)
a. Dependent Variable: RTV
b. Predictors: (Constant), LCA

Table 5: Result of Linear Regression/Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.656	1.319		.498	.622
	LCA	.988	.015	.996	64.455	.000

Source: (SPSS Version 25)
a. Dependent Variable: RTV

The regression model result presented in Table 3 evaluates the effect of Life Cycle Assessment (LCA) on RTV. The correlation coefficient ($R = 0.996$) confirms a very strong association between the independent and dependent variables.

In addition, Table 3 of the R^2 value of 0.992 suggests that LCA explains about 99.2% of the changes in RTV, stressing the model's exceptional explanatory capability. The remaining 0.8% was because of changes not captured in the model, indicating that the model is perfect fit. The identical adjusted R^2 value confirms the consistency and robustness of the model, indicating negligible inflation of explained variance.

Table 4 reports a statistically significant ANOVA result for the regression model predicting RTV from LCA. The high F-value (4154.392) and the significance level below 0.05 indicate that the model explains a significant proportion of variance in RTV, confirming LCA as a significant predictor.

Table 5 reports a significant positive relationship between LCA and RTV. The regression coefficient and standardized beta value indicate a strong predictive effect, supported by a highly significant t-value and p-value below 0.05.

3.1.4 Discussion

The regression model was used in testing and analyzing third research hypotheses. Result indicate that Life Cycle Assessment (LCA) and real time visibility (RTV) are statistically signification. The correlation coefficient is confirmed when ($R = 0.996$; R^2 value of 0.992) indicating a very strong association between the independent and dependent variables. In addition, high F-value (4154.392) and the significance level below 0.05 indicate that the model explains a significant proportion of variance in RTV, confirming LCA as a significant predictor. Findings is in agreement with previous studies by Adebayo and Ojo (2023), indicating that integrating LCA tools improved real-time visibility of environmental data, facilitating improved decision-making in energy and waste management. Findings also align with the literature, previous work of Okon and Bello (2022), specifying that LCA frameworks strengthened real-time monitoring systems, ensuring effective waste tracking and emission reporting. Given the above the result, study confirms alignment between the study's outcomes and the literature.

4. Conclusion

4.1 Conclusion

The results of the hypothesis showed that there is a significant relationship between Life Cycle Assessment (LCA) and Real Time Visibility (RTV). Combining Life Cycle Assessment with real-time visibility enhances the effectiveness of environmental monitoring and decision making throughout the product life cycle. The finding suggests that organizations that implement LCA with the support of real-time visibility systems are better able to monitor environmental impacts, increase supply chain transparency, optimize resource utilization, and improve sustainability performance. Therefore, the study conclude that the combined use of Life Cycle Assessment and real-time visibility has a significant impact on better organizational and environmental performance.

4.2 Recommendations

The following recommendations are stated below. (1) Maritime universities should adopt ISO 14040 and ISO 14044 standards for evaluating the environmental impacts of campus operations, procurement, laboratory activities, training vessels, and infrastructure projects. (2) Universities management should invest in IoT sensors, RFID, GPS tracking, cloud-based inventory systems, and digital dashboards to provide real-time monitoring of assets, equipment, logistics operations, and environmental performance. (3) There need to implement integrated logistics management platforms capable of tracking procurement processes, laboratory inventories, maintenance schedules, energy consumption, and waste management in real time. (4) It is important to organize regular training programmes for lecturers, researchers, technical staff, and students on LCA software (e.g., SimaPro, OpenL CA, GaBi) and real-time visibility technologies.

4.3 Contribution to Knowledge

Furthermore, the study contributes to the literature by extending the use of Institutional Theory in explaining the effect of institutional pressures, organizational commitment and regulatory compliance on the adoption of sustainable procurement practices. More specifically, it shows how compliance with procurement policies and environmental regulations can assist in the integration of Life Cycle Assessment into procurement decisions for the purpose of improving environmental sustainability and reducing the negative environmental consequences. Thus, this study filled the contextual gap in the previously neglected studies using Nigerian maritime education sector.

4.4 Practical Implication of the Study

Government agencies such as the Federal Ministry of Education, Federal Ministry of Marine and Blue Economy, Nigerian Maritime Administration and Safety Agency (NIMASA), and National Universities Commission (NUC) can develop sustainability policies requiring maritime institutions to implement digital environmental monitoring systems.

4.5 Future Research

Future research should evaluate the environmental impacts of academic activities, campus logistics, energy consumption, waste management, laboratory operations, and procurement practices. Again, future studies involving multiple maritime universities across different geopolitical zones of Nigeria to enhance the generalizability of findings is suggested.

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