Assessing the Adoption of Digital Technologies for Logistics and Supply Chain Management among Selected International Non-Governmental Organizations (INGOs)

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ABSTRACT

This study assessed the adoption of digital technologies in enhancing circular supply chain and logistics management among selected International Non-Governmental Organizations (INGOs) in Abuja, Nigeria. The study was motivated by the growing need for improved efficiency, transparency, and sustainability in humanitarian logistics operations, particularly in alignment with circular economy principles and global sustainability goals. A mixed-methods research design was adopted, combining quantitative data from structured questionnaires with qualitative insights from in-depth interviews to provide a comprehensive analysis of digital adoption patterns, operational outcomes, barriers, and enabling factors. The findings revealed that while basic digital tools such as enterprise resource planning systems, digital tracking platforms, and data management systems are moderately adopted, advanced technologies such as artificial intelligence, blockchain, and Internet of Things applications remain underutilized. Digitalization was found to significantly enhance resource optimization, waste reduction, reverse logistics practices, transparency, and overall sustainability performance. However, constraints including limited funding, inadequate technical expertise, infrastructural deficits, and organizational resistance to change were identified as major barriers to full digital transformation. The study concludes that strategic investment in digital capacity building, infrastructure, and policy support is essential for strengthening circular supply chain performance and sustainability outcomes within INGOs operating in developing country contexts.

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Keywords: Digitalization, Circular Supply Chain, Logistics Management, International Non-Governmental Organizations (INGOs), Sustainability

INTRODUCTION

The logistics and supply chain functions of International Non-Governmental Organizations (INGOs) play a critical role in ensuring timely delivery of humanitarian aid and relief materials to vulnerable populations affected by disasters, conflicts, and complex emergencies. In recent years, many INGOs have increasingly recognised the transformative potential of digital technologies — such as cloud platforms, artificial intelligence (AI), data analytics, and Internet of Things (IoT) — to improve operational efficiency, visibility, and responsiveness in humanitarian logistics (Shrivastav & Bag, 2023; Ahatsi & Olanrewaju, 2025). These technologies help organisations adapt to increasingly complex supply chain networks, where rapid decision-making and real-time coordination are essential for effective service delivery (John et al., 2025a; 2025b). The integration of such tools into logistical processes has become not just an innovation but a necessity for achieving organisational goals in a dynamic and resource-constrained environment (Abdullahi et al., 2024; Oluwalosijibomi et al., 2025).

The adoption of digital technologies in logistics and supply chain management brings numerous advantages to INGOs, including enhanced supply chain agility, improved collaboration among stakeholders, and greater transparency in operations (Yıldız & Bıyıklı, 2026). Digital tools enable real-time tracking of goods, predictive forecasting of demand, and seamless coordination between local and international partners (Imam-Binuyo et al., 2026).

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For instance, AI and big data analytics have been shown to significantly strengthen humanitarian supply chain resilience by improving forecasting accuracy and optimising resource allocation (Ahatsi & Olanrewaju, 2025). Such capabilities are pivotal in contexts where delays or misallocation of resources can have severe humanitarian consequences. Consequently, exploring how and to what extent INGOs adopt these technologies is crucial for identifying best practices that can be replicated across organisations.

Despite the evident benefits, INGOs face significant challenges in adopting digital technologies, including limited infrastructure, high implementation costs, and shortages of technical expertise (Usman, 2023; Salomonsson, 2018). Literature on humanitarian logistics consistently highlights that technological barriers such as insufficient policies, lack of trained staff, and budgetary constraints hinder the seamless integration of digital innovation into supply chain practices. These challenges are particularly acute in developing contexts where organisational capacities are already stretched by operational demands and resource scarcity. Understanding these obstacles is essential for designing interventions that can support INGOs in overcoming adoption barriers and building sustainable digital capabilities.

Moreover, the adoption process among INGOs is shaped not only by technological considerations but also by organisational and environmental factors that influence implementation outcomes (Yang, 2021). Scholars note that successful adoption depends on the alignment between the organisation's strategic objectives and its readiness to embrace digital transformation. Factors such as leadership support, training initiatives, and collaborative networks with external partners play pivotal roles in enabling INGOs to leverage digital technologies effectively. These determinants underscore the importance of comprehensive assessments that go beyond technological availability to include organisational culture and stakeholder engagement.

Given the dynamic nature of humanitarian supply chains and the rapid evolution of digital technologies, assessing the adoption of these innovations within select INGOs is timely and necessary. A deeper investigation can reveal how INGOs prioritise specific technologies, the extent of their integration into logistical processes, and the benefits and challenges experienced in practice. Such research not only enriches academic discourse on digital transformation in humanitarian operations but also offers practical insights for policymakers and humanitarian

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Conceptual Framework

2.1.1 Digital Technologies

Digital technologies refer to electronic tools, systems, devices, and resources that generate, store, or process data and enable automation, connectivity, and real-time communication across organizational functions. These technologies include artificial intelligence (AI), big data analytics, blockchain, cloud computing, Internet of Things (IoT), and enterprise resource planning (ERP) systems, which are increasingly transforming operational processes across sectors (Verhoef et al., 2021; Vial, 2019). Digital technologies facilitate improved decision-making through data-driven insights, enhance transparency, and support integration across complex networks. In supply chain environments particularly, they enable real-time tracking, predictive analytics, automation of warehouse operations, and improved coordination among stakeholders. As organizations pursue digital transformation, digital technologies serve as enablers of innovation, operational efficiency, and competitive advantage by reshaping business models and service delivery systems (Verhoef et al., 2021).

2.1.2 Logistics and Supply Chain Management

Logistics and Supply Chain Management (SCM) encompass the planning, implementation, and control of the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption to meet customer or beneficiary requirements. Logistics focuses primarily on transportation, warehousing, inventory management, and distribution, while supply chain management integrates these activities with procurement, production, and coordination among multiple stakeholders (Christopher, 2016; Council of Supply Chain Management Professionals [CSCMP], 2023). Effective SCM emphasizes integration, collaboration, and visibility across the supply chain network to enhance responsiveness and reduce costs. In humanitarian and development contexts, logistics and SCM are critical for ensuring timely delivery of relief materials and essential services, often under conditions of uncertainty

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and resource constraints. Modern supply chains increasingly rely on digital tools to improve agility, resilience, and transparency across interconnected global networks (Christopher, 2016).

2.1.3 International Non-Governmental Organizations (INGOs)

International Non-Governmental Organizations (INGOs) are independent, non-profit organizations that operate across national boundaries to address humanitarian, developmental, environmental, and human rights issues. Unlike governmental agencies, INGOs are privately governed and funded through donations, grants, and partnerships, although they may collaborate closely with governments and multilateral institutions. According to United Nations (2022), NGOs and INGOs play a vital role in supporting sustainable development, humanitarian response, and advocacy initiatives worldwide. INGOs typically operate in complex and high-risk environments, requiring robust coordination mechanisms and efficient supply chain systems to deliver aid effectively. Scholars note that accountability, transparency, and operational efficiency are central to INGO performance, particularly given donor expectations and beneficiary needs (Anheier, 2014). As a result, many INGOs are increasingly adopting digital innovations to strengthen governance, monitoring, evaluation, and logistical operations in order to enhance impact and sustainability.

2.2 Theoretical Review

2.2.1 Technology–Organization–Environment (TOE) Framework,

Technology–Organization–Environment (TOE) Framework, developed by Louis G. Tornatzky and Mitchell Fleischer. The TOE framework posits that an organization's adoption of technological innovation is influenced by three contextual factors: technological factors (perceived benefits, compatibility, and complexity of the technology), organizational factors (size, resources, managerial support, and technical expertise), and environmental factors (industry characteristics, competition, regulatory environment, and external pressure) (Tornatzky & Fleischer, 1990). In the context of assessing the adoption of digital technologies for logistics and supply chain management among International Non-Governmental Organizations (INGOs), the TOE framework provides a comprehensive lens for understanding how internal capabilities (such as digital skills and leadership commitment), technological readiness (such as availability of AI, IoT, or cloud systems), and external pressures (such as donor requirements, regulatory policies, and humanitarian urgency) collectively influence adoption decisions (Ajibola et al., 2025). The framework has been widely applied in studies examining digital transformation and innovation adoption across sectors, including supply chain management, due to its robustness in explaining organizational-level technology adoption (Baker, 2012). Therefore, the TOE framework offers a suitable theoretical foundation for analyzing the determinants and extent of digital technology adoption within selected INGOs.

2.3 Empirical Review

Nyirigira (2025) investigated the adoption of digital technologies in humanitarian supply chains using a mixed-methods design with 108 ADRA Rwanda staff respondents and key informant interviews. The study found that basic digital tools like barcode scanning and manual tracking were widely used, while advanced solutions like RFID, cloud platforms, AI, and IoT were underutilised. Regression analysis showed that technology use significantly improved operational efficiency, monitoring, and forecasting. The author recommended broader adoption of emerging technologies to enhance real-time visibility and supply chain performance in resource-constrained environments (Nyirigira, 2025). (kuey.net)

Alhindawi et al. (2025) conducted an empirical quantitative analysis of 999 supply chain operations to assess how technologies such as AI and blockchain affect supply chain agility and resilience. The results indicated that technology adoption positively influenced agility ($\beta = 1.77$, $p < 0.001$) and reduced lead time variability, suggesting tangible performance benefits. The authors recommended longitudinal studies to better understand long-term outcomes of digital technology adoption across different industries. While not INGO-specific, the findings offer insights relevant to supply chain improvements through digital innovation (Alhindawi et al., 2025). (posthumanism.co.uk)

Data-Driven Digital Transformation Study (2023) surveyed 296 NGOs involved in humanitarian operations, applying PLS-SEM analysis to test resource dependence theory variables. The study found that digital technology application in sourcing, distribution, and material flow significantly mediated the

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relationship between donor confidence and humanitarian supply chain antifragility. Trust and effective governance were critical moderators, enhancing the positive effect of digital tools on operational robustness, and the authors recommended targeted governance frameworks to foster technology confidence in NGOs (International Journal of Production Economics, 2023). (ScienceDirect)

State of Logistics Humanitarian Survey Report (2024) collected data from humanitarian organisations worldwide, revealing significant barriers to advanced digital adoption. The survey found that insufficient funding, inadequate IT infrastructure, and limited training were leading obstacles to AI and automation uptake in supply chains. Although mobile devices and cloud computing were increasingly used, most organisations reported limited use of higher-level technologies. The report recommended investment in infrastructure and training to accelerate digital transformation in humanitarian logistics (HELP Logistics Report, 2024). (help-logistics.org)

State of Logistics Global Survey (2025) highlighted the slow uptake of AI tools in humanitarian supply chains, with over 80% of respondents indicating rare usage across supply chain functions. The report also noted rising barriers such as funding shortages and unclear technology policy frameworks. The findings emphasized that technology adoption remains low despite widespread recognition of digital tools' potential, and the authors called for strategic policy interventions and donor support mechanisms to facilitate digital adoption (HELP Logistics Report, 2025). (help-logistics.org)

Damavandi et al., 2025 used a DEMATEL approach with expert panels to empirically model barriers to blockchain adoption in food bank supply chains, a context similar to INGO logistics systems. Although not specifically within INGOs, this study identified internal and external barriers affecting digital adoption and concluded that overcoming these barriers — such as uncertainty and feedback complexity — is critical for blockchain technologies to improve transparency and operations. The authors recommended participatory strategies to manage adoption challenges and enhance stakeholder buy-in (Damavandi et al., 2025). (arXiv)

2.4 Gaps in Literature

Although existing empirical studies have examined digital transformation in supply chains and humanitarian logistics, significant gaps remain that justify the present study. For instance, Nyirigira (2025) focused on operational efficiency within a single humanitarian organization (ADRA Rwanda), thereby limiting generalizability across diverse International Non-Governmental Organizations (INGOs). Similarly, Alhindawi et al. (2025) and the International Journal of Production Economics (2023) study concentrated on technology adoption and supply chain agility or antifragility largely within commercial or generalized humanitarian contexts, without isolating INGOs as a distinct organizational category with unique governance structures, donor dependencies, and accountability requirements. Furthermore, the HELP Logistics (2024, 2025) reports primarily provided descriptive survey insights on digital adoption trends and barriers but lacked rigorous inferential analysis linking organizational, technological, and environmental determinants to measurable logistics performance outcomes. Damavandi et al. (2025) examined blockchain adoption in food bank supply chains, yet the scope was technology-specific and not comprehensive of broader digital transformation practices. Overall, prior studies either focus narrowly on single technologies, single organizations, or general humanitarian settings without offering a comparative, multi-organization assessment of digital technology adoption specifically among selected INGOs. Consequently, there is limited empirical evidence integrating determinants of adoption, extent of implementation, and logistics performance outcomes within INGOs, thereby creating a clear research gap that this study seeks to address.

RESEARCH METHOD

3.1 Research Design

This research will adopt the pragmatist approach, which accommodates both positivist and interpretivist approaches, integrating both quantitative (survey-based) and qualitative (interview-based) methods to explore how digital technologies contribute to circular supply chains in humanitarian logistics. As some research experts argue, it is possible and often highly appropriate to employ both approaches within a single research study (Creswell & Poth, 2018; Frost, 2021).

Creswell and Poth (2018) argue that pragmatism as a research philosophy supports deductive reasoning and the use of a mixed research approach, acknowledging the suitability of employing this

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method in this type of research. In the context of this study, choosing mixed research methods is considered scientifically appropriate, as it will allow for methodical investigation of the extent to which digital technologies influence circular supply chains in the humanitarian sector, aligning with the research's aim and objectives. A key justification for proposing this philosophy is its integration of multiple research methods, such as qualitative and quantitative approaches, to answer research questions. Tashakkori et al. (2021) suggest that while there are different research philosophies, it is prudent to view as a continuum rather than as opposites. They also note that at certain points in a study, researchers must engage with the research, while at other points, they must maintain independence. The main justification for the choice of this philosophy however, stems from its ability to provide a systematic and structured way to analyze the relationship between the main variables of the study allowing both quantitative and qualitative analysis to identify trends, patterns, and relationships between variables, thereby enhancing the reliability and validity of the findings.

A mixed-methods approach will be employed in this study to capture both statistical trends and in-depth perspectives on digital transformation in circular supply chains. The study integrates quantitative approach (survey) to measure the impact of digital technologies on key circular supply chain metrics such as waste reduction, carbon footprint, and supply chain transparency, and the qualitative approach (case studies and interviews) to explore real-world implementation, challenges, and success factors in humanitarian organizations. This combination will enhance the study's validity and reliability by ensuring that quantitative findings are complemented with qualitative insights.

Phase 1: Quantitative Survey

In this phase, a structured questionnaire will be distributed to supply chain, logistics and operations personnel in five selected international humanitarian organizations operating in Nigeria with head offices in Abuja to assess the role of digital transformation in circular supply chain management.

Phase 2: Qualitative Case Studies and Interviews

Case studies of five selected humanitarian organizations operating in Nigeria will be conducted to examine real-world applications. Semi-structured interviews with key stakeholders provide further insights into the challenges and best practices.

3.3 Population and Sampling

Research population refers to the aggregate number of people and objects that share similar characteristics and becoming the target of focus of scientific enquiry (Stratton, 2021; Levitt, 2021).

3.3.1 Target Population

To ensure a comprehensive and representative analysis of digitization and circular supply chain management in humanitarian logistics, this study will focus on five international non-governmental organizations (INGOs) operating in Nigeria since the last 5 years (2020 - 2025). The statistical population will consist of 100-150 mid to senior level professional staff of supply chain, logistics-related departments of the selected organizations. The selected organizations are:

- International Committee of the Red Cross (ICRC)
- World Food Programme (WFP)
- Doctors Without Borders (MSF)
- Norwegian Refugee Council (NRC), and
- UNICEF

The INGOs were selected based on five main parameters – relevance to the topic under investigation, commitment to sustainability, operational presence and scale of activities in the study area, availability of data and willingness to participate, and supply chain models.

The target population include Logistics Coordinators, IT Specialists involved in digital supply chain transformation, Procurement, Supply Chain and Logistics Managers, IT professionals involved in digital supply chain transformation, Field operations officers managing supply chain sustainability initiatives.

The main rationale for choosing this statistical population is to ensure that the study is focused, relevant, and able to provide meaningful insights into the digitization and circular supply chains in the humanitarian sector by focusing on qualified and experienced professional staff with the requisite knowledge to provide

relevant answers to questions contained in the questionnaire. This is in line with the view Frankfort-Nachmias, Leon-Guerrero and Davis (2020) which posit that choosing a statistical population is essential for achieving validity, reliability, and generalizability of research findings, as well as for ethical considerations.

3.3.2 Sampling Technique

A purposive sampling technique will be employed to select participants with direct experience in supply chain digitalization within humanitarian organizations. The sample is drawn from five major humanitarian organizations engaged in digital transformation initiatives. The study will focus specifically on supply chain-related functional areas of the selected organizations due to their operational relevance to the variables under investigation. For quantitative data, a stratified random sampling approach will be used to ensure representation across different functional areas of the supply chain (e.g., procurement, warehousing, transport, and IT). The research will select 100–150 respondents from the five selected INGOs. For qualitative data, a purposive sample of case study organizations and interview participants will be selected based on their experience in implementing digital tools in circular supply chain operations. 10-15 key respondents will be selected for in-depth interviews.

3.4 Data Collection Methods
The study will employ primary and secondary data collection methods to ensure a robust analysis.

3.4.1 Primary Data Collection
Structured questionnaire: To collect empirical data for this study, a structured questionnaire will be employed as the primary instrument for quantitative data collection. A comprehensive question with close-ended items formatted on a 5-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5) will be used to collect quantitative data on digital technology adoption, circular supply chain practices, and environmental sustainability outcomes. This format facilitates the quantification of attitudes and behaviors while enabling statistical analysis of the relationships among key constructs**.**
Semi-structured interviews: in-depth interviews will be conducted with key personnel to explore the drivers, challenges, and impact of digital transformation in humanitarian supply chains.

3.4.2 Secondary Data Collection
Secondary data (e.g., reports, policies, and operational documents) from humanitarian organizations implementing digital supply chain solutions. Academic journal articles on digital transformation in humanitarian logistics. Reports from UN agencies, NGOs, and industry bodies on supply chain digitization. Policy documents and sustainability reports from selected case study organizations.

3.5 Data Analysis Techniques
A combination of quantitative and qualitative data analysis techniques will be used to analyze the data collected from respondents:

3.5.1 Quantitative Data Analysis
Quantitative data collected for the study will be analyzed using statistical tools from the Statistical Package for Social Science (SPSS). This software is widely used in social science research for its ability to handle large datasets and perform complex statistical analyses (Healy, 2019). Descriptive statistics (mean, standard deviation, frequency analysis) will be used to summarize and describe the survey responses, providing a clear picture of the key trends and patterns in the data. While inferential statistics will be used to examine relationships between variables – digital technology adoption and circular supply chain performance. Hypothesis Testing (H_o and H_1): Hypotheses will be tested using a 95% confidence interval (α = 0.05). The p-values will be interpreted to determine statistical significance, with $p < 0.05$ indicating rejection of the null hypothesis.

Furthermore, the results of the analysis will be presented using graphs, charts, and tables. Visual representations of the data can often help to convey complex information more clearly and effectively than text alone (Pallant, 2020). Graphs and charts will be used to illustrate the distribution of responses and highlight any significant trends or patterns. Tables will used to present numerical data in a structured

format, making it easier for readers to compare and interpret the results. Following the presentation of the results, a textual analysis will be done to further explore and interpret the findings. This involves a detailed examination of the data, looking for any underlying themes or patterns that emerged (Braun & Clarke, 2019). The textual analysis will help to provide a more nuanced understanding of the data and allowed for a more in-depth discussion of the key findings. The choice of SPSS for data analysis in this study is essential for generating meaningful insights into the role of digital technology adoption and circular supply chain management in selected INGOs in Abuja. By employing a robust statistical analysis, the study will be able to provide a comprehensive and evidence-based assessment of the research topic.

3.5.2 Qualitative Data Analysis
Thematic analysis of interview transcripts to identify common patterns and themes related to digital transformation challenges and best practices.

3.6.1 Reliability
Reliability assesses the consistency and stability of a research instrument over time, ensuring that repeated measurements yield similar results (Bolarinwa, 2015). It can be evaluated through test-retest reliability, inter-rater reliability, and internal consistency. Test-retest reliability involves administering the same instrument at different time points and calculating the correlation coefficient to determine consistency. Inter-rater reliability measures the level of agreement between different evaluators assessing the same phenomenon. For this study, internal consistency will be assessed using Cronbach's Alpha, a widely used measure of reliability. A Cronbach's Alpha coefficient of 0.7 or higher is considered acceptable, indicating that the questionnaire items are adequately correlated and measure the intended constructs reliably (Tavakol & Dennick, 2011). Additionally, a pilot test will be conducted with 10 supply chain professionals to ensure that the questionnaire is clear, comprehensible, and free from ambiguities. Feedback from the pilot test will inform necessary refinements before full-scale data collection.

3.6.2 Validity
Validity refers to the accuracy of findings and interpretations (Offurum, Emerole, Osuala & Emerole, 2024). Content validity is ensured by aligning survey questions with established frameworks on supply chain digitalization and circular economy principles (Afolabi, 2021). Construct validity will be confirmed through expert review and feedback from academic professionals in supply chain management (Flake, Davidson & Pek, 2022). The study will take steps to ensure internal validity by using a Content Validity Index (CVI) to measure the research instrument by evaluating how well the items represent the construct (Lim, 2024) being measured. The CVI is derived by:

$$CVI = \left(\frac{\text{Number of experts who rate an item as relevant}}{\text{Total number of experts}} \right) \times 100$$

For instance, if 8 out of 10 experts agree on the relevance of an item, the CVI is 80%, indicating strong validity (Lim, 2024). According to Offurum et al. (2024), content validity is a methodological approach rather than a statistical test. This study will use a panel of 10 subject-matter experts to assess the questionnaire, with an acceptability threshold of I-CVI ≥ 0.78, indicating that the instrument has strong content validity.

3.7 Ethical Considerations
Ethical considerations are fundamental to conducting responsible research, ensuring the protection of participants' rights, data integrity, and adherence to professional ethical standards. According to Steneck (2007), ethical research practices emphasize informed consent, confidentiality, and participant autonomy, all of which have been strictly observed in this study. Participants were provided with comprehensive information about the research objectives, methods, and their rights before participation. They were explicitly informed that their involvement was voluntary, and they had the unrestricted right to withdraw at any stage without any repercussions.

To ensure confidentiality and data security, participants' responses will be anonymized, and personal identifiers will be removed from all research records. Data collected will be stored securely and used exclusively for academic purposes, with access restricted to authorized personnel only. This aligns

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with best practices in ethical research, which emphasize the responsible handling of sensitive data to prevent unauthorized access or misuse (Bryman, 2016).

Furthermore, this study will adhere to ethical principles that safeguard participant welfare and minimize potential harm. Ethical guidelines mandate that research should not expose participants to physical, psychological, or social risks (Resnik, 2020). In this regard, measures will be implemented to ensure that participation does not result in stress, coercion, or any form of harm. Cultural sensitivity and inclusivity will also be prioritized, ensuring that research materials and engagement approaches were respectful and non-discriminatory.

Additionally, transparency, integrity, and accountability are central to this research. The study will comply with institutional and professional ethical guidelines, ensuring researcher impartiality and the accurate representation of findings. Any potential conflicts of interest will be disclosed, and data handling procedures align with established ethical research frameworks. By upholding these ethical principles, this study will ensure the credibility of research findings while maintaining the highest standards of integrity in academic inquiry.

3.8 Model Specification

This study investigates the relationship between digitization technologies and circular supply chain performance (CSCP) by employing a multiple regression model. The model evaluates how key digitization technologies—big data analytics (BD), Internet of Things (IoT), artificial intelligence (AI), blockchain (BC), and enterprise resource planning (ERP)—impact the efficiency and sustainability of circular supply chain operations. These technologies play a crucial role in optimizing various aspects of circular supply chain management (Queiroz et al., 2020):

To quantify these relationships, a multiple regression model is used, which is specified as follows:

$CSCP = \beta_0 + \beta_1 BD + \beta_2 IoT + \beta_3 AI + \beta_4 BC + \beta_5 ERP + \beta_6 SDG + \varepsilon$

Where:

CSCP = Circular Supply Chain Performance (Dependent Variable)

BD = Big Data Analytics (Independent Variable)

IoT = Internet of Things (Independent Variable)

AI = Artificial Intelligence (Independent Variable)

BC = Blockchain Technology (Independent Variable)

ERP = Enterprise Resource Planning (Independent Variable)

β_0 = Intercept

$\beta_1 - \beta_5$ = Coefficients of independent variables

ε = Error term (captures unobserved factors affecting CSCP)

This model aims to assess the extent to which digitization enhances circular supply chain efficiency by minimizing waste, optimizing reverse logistics, and promoting resource sustainability. The regression results will provide empirical insights into how different digital technologies contribute to the performance, resilience, and environmental sustainability of circular supply chains.

3.9 Measurement of Variables

The study employs both primary and secondary data to measure the variables. Primary data is collected through a structured questionnaire using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), targeting supply chain professionals in industries that have adopted circular economy principles. Secondary data, including industry reports, case studies, and academic research, will be used to complement primary data, providing a more comprehensive understanding of the relationship between digitization and circular supply chain performance.

The variables and their measurement indicators are summarized in the table below:

Variable			Type	Measurement	Indicator
Circular Supply Performance (CSCP)		Chain	Dependent	Likert Scale (1-5)	Efficiency, waste reduction, reverse logistics effectiveness, carbon footprint reduction,

				sustainable resource utilization
Big Data Analytics (BD)	Independent	Likert Scale (1-5)		Data-driven decision making, predictive analysis
Internet of Things (IoT)	Independent	Likert Scale (1-5)		Real-time tracking, smart inventory
Artificial Intelligence (AI)	Independent	Likert Scale (1-5)		Automation, demand forecasting
Blockchain Technology (BC)	Independent	Likert Scale (1-5)		Transparency, traceability
Enterprise Resource Planning (ERP)	Independent	Likert Scale (1-5)		process integration, green supply chain management, sustainable decision support
Sustainability Contributions (SDG Impact)	Independent	Likert Scale (1-5)		Carbon emission reduction, resource efficiency, circular economy adoption

Table 3.1: Research Variables
Source: Adapted from relevant literature on digital transformation in supply chain management

3.10 Estimation Technique

This study employs multiple regression analysis to examine the relationship between digitization technologies and circular supply chain performance (CSCP) in enhancing environmental sustainability, aligning with SDGs 12 and 13. The regression model is specified as follows:

$$CSCP = \beta_0 + \beta_1 BD + \beta_2 IoT + \beta_3 AI + \beta_4 BC + \beta_5 ERP + \beta_6 SDG + \epsilon$$

The justification for selecting Multiple Regression Analysis is that it will allow for quantifying the impact of multiple digitization technologies on circular supply chain performance, and also assessing the relative influence of each independent variable on sustainability outcomes. This technique will also identify significant predictors of circular supply chain success in achieving environmental sustainability.

The estimation results are expected to show a positive and significant relationship between digitization and circular supply chain performance. A high R-squared value will indicate that digitization technologies, along with sustainability contributions (SDG impact), significantly enhance circular supply chain efficiency, waste reduction, and environmental sustainability.

These findings will provide valuable insights for supply chain professionals, policymakers, and industry leaders, supporting data-driven decisions to optimize digitization for sustainable supply chain and logistics management in alignment with SDGs 12 and 13.Limitations of the Study.

RESULTS AND DISCUSSION

Item	Description
Total questionnaires distributed	100
Completed and returned	50
Response rate	50%
Respondent departments	Supply Chain, Logistics, Procurement, ICT, Field Operations
Data analysis tools	SPSS (Descriptive & Inferential Statistics)
Statistical outputs	Means, Standard Deviations, Skewness, Kurtosis
Inferential tests	Correlation, Regression
Supplementary data	Qualitative insights from interviews
Purpose of analysis	To assess digital adoption, circular supply chain practices, and sustainability outcomes across INGOs in Abuja

Table 4.1: Summary of Survey Response and Data Analysis Approach
Source: Field Survey (2025)

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While moderate, this level of participation is acceptable for organizational research of this scale and provides a sufficiently reliable dataset for meaningful analysis (Baruch & Holtom, 2018). The respondents came from diverse departments—such as supply chain, logistics, procurement, ICT, and field operations - ensuring broad representation of perspectives within humanitarian supply chains in Abuja. The quantitative data collected were analyzed using SPSS, which generated descriptive statistics including means, standard deviations, skewness, and kurtosis, as well as inferential measures such as correlation and regression analyses. These analytical techniques are commonly applied in supply chain research to examine adoption patterns, assess variability, and test relationships between digitalization and sustainability outcomes (Bag et al., 2021). The findings are presented in tables and figures, supported by interpretive discussions that incorporate qualitative evidence from the interviews. This mixed analytical approach provides a more comprehensive understanding of how INGOs in Abuja are adopting digital tools, integrating circular supply chain practices, and navigating the associated barriers and enablers in pursuit of sustainability goals.

4.2.1 Demographics and Participant Characteristics

This section provides information about the respondents, including their roles, education levels, departments, and years of experience.

Variable	Category	f	%
Role	Supply Chain Manager	5	10.0
	Logistics Coordinator	13	26.0
	Procurement Officer	16	32.0
	IT Specialist	7	14.0
	Field Operations Officer	9	18.0
Education	Diploma	11	22.0
	Bachelor's Degree	21	42.0
	Master's Degree	12	24.0
	PhD	6	12.0
Department	Supply Chain	7	14.0
	Logistics	17	34.0
	Operations	11	22.0
	ICT	9	18.0
	Transport	6	12.0
Years of experience	Less than 2 years	15	30.0
	2–5 years	12	24.0
	6–10 years	11	22.0
	Above 10 years	12	24.0

Table 4.2: Respondents' profile
Source: Field Survey (2025)

The respondent characteristics provide important context for interpreting the findings. Functionally, the largest groups were procurement officers (32%) and logistics coordinators (26%), with additional representation from field operations (18%), ICT (14%), and supply chain managers (10%). This distribution reflects the diverse roles engaged in humanitarian logistics, ensuring insights were captured from both strategic and operational perspectives. Educationally, most respondents held at least a bachelor's degree (42%), with 24% having a master's and 22% a diploma, indicating a workforce with sufficient academic grounding to engage with digital and sustainability issues. Departmentally, operations (34%) and logistics (14%) were most represented, while ICT (18%), supply chain (12%), and transport (12%) contributed perspectives central to digital adoption and circular practices. Experience levels were balanced, with 30% having less than two years and 46% more than six years, ensuring a mix of fresh perspectives and institutional knowledge. Overall, the diversity of roles, qualifications, and experience strengthens the credibility of the results.

4.3 Descriptive Statistics

This section presents the descriptive statistics of the study, providing an overview of the key variables relevant to the research. Descriptive analysis helps to summarize the data in terms of frequencies, percentages, and averages, offering insights into patterns and distributions that set the foundation for further inferential analysis.

4.3.1 Digital Technology Adoption (RQ1)

Table: 4.3: Descriptive Statistics for Digital Technology Adoption

	N	Min	Max	Mean	
	Stat	Stat	Stat	Stat	Std. Error
Our organization has adopted ERP systems to manage supply chain operations.	50	1.00	5.00	3.5200	.20651
Data analytics tools are used to support decision-making.	50	1.00	5.00	3.1600	.19662
We use IoT devices for tracking goods and monitoring conditions	50	1.00	5.00	3.1400	.19380
Blockchain is used to ensure transparency and traceability in our supply chain.	50	1.00	5.00	2.9000	.20849
AI or machine learning tools are used for forecasting and planning logistics activities.	50	1.00	5.00	2.5400	.18341
Valid N (listwise)	50				

Source: SPSS Output, Field Survey (2025)

Table 4.3 presents the descriptive statistics for the adoption of key digital technologies in supply chain and logistics management. ERP systems recorded the highest mean score (M = 3.52, SD = 1.46), indicating relatively mature adoption, though responses were widely dispersed. Data analytics (M = 3.16, SD = 1.39) and IoT tools (M = 3.14, SD = 1.37) showed moderate adoption, reflecting growing but uneven integration across organizations. Blockchain (M = 2.90, SD = 1.47) and AI/ML (M = 2.54, SD = 1.29) had the lowest scores, with positive skewness values showing clustering around lower adoption levels.

Overall, the results suggest a hierarchy in digital uptake: ERP is well established, analytics and IoT are emerging, while blockchain and AI/ML remain nascent. The variability across all technologies indicates uneven digital maturity shaped by differences in organizational capacity and priorities. Importantly, the underutilization of IoT, blockchain, and AI/ML constrains progress toward transparency, traceability, and predictive efficiency—capabilities that are critical for advancing circular supply chain practices and achieving SDGs 12 and 13.

4.4 Enablers of Digital Adoption

Table 4.4: Descriptive Statistics for Enablers of Digital Adoption

	N	Min	Max	Sum	Mean	
	Stat	Stat	Stat	Stat	Stat	Std. Error
Training of staff on digital tools	50	1.00	5.00	164.00	3.2800	.20211
Government policies support digitalization	50	1.00	5.00	154.00	3.0800	.19967
Valid N (listwise)	50					

Source: SPSS Output, Field Survey (2025)

Table 4.4b: Descriptive Statistics for Enablers of Digital Adoption

	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Training of staff on digital tools	1.42914	-.475	.337	-1.083	.662
Government policies support digitalization	1.41190	-.102	.337	-1.297	.662
Valid N (listwise)	50				

Source: SPSS Output, Field Survey (2025)

The findings show that staff training on digital tools is the strongest enabler of adoption (M = 3.28, SD = 1.43), followed by supportive government policies (M = 3.08, SD = 1.41). The negative skewness values suggest a leaning towards higher agreement on their importance, while the negative kurtosis indicates dispersed responses across INGOs. Overall, this highlights that capacity-building initiatives and policy support play a key role in driving digital adoption, though effectiveness varies widely among organizations.

4.5 Correlation Analysis

Correlation analysis was conducted to examine the relationships between digital adoption, circular practices, sustainability outcomes, barriers, and enablers. The results consistently show strong and significant positive relationships within digital adoption variables, within circular practices, and between sustainability outcome measures. However, weaker or non-significant relationships were observed between SDG13 risk integration and other variables, suggesting a gap in climate risk mainstreaming. The following sections present a summary of the correlation results. See appendices for more details from SPSS output.

4.5.1 Digital Adoption Correlations

Variable Pair	Pearson Correlation (r)	Significance (p)
ERP – Data Analytics	.933**	.000
ERP – IoT	.942**	.000
ERP – Blockchain	.925**	.000
ERP – AI/ML	.872**	.000
Data Analytics – IoT	.952**	.000
Data Analytics – Blockchain	.954**	.000
Data Analytics – AI/ML	.924**	.000
IoT – Blockchain	.947**	.000
IoT – AI/ML	.933**	.000
Blockchain – AI/ML	.947**	.000

Table 4.8: Correlations for digital adoption
Source: SPSS Output, Field Survey (2025)

The correlations among digital adoption variables (ERP, Data Analytics, IoT, Blockchain, and AI/ML) are all strong and statally significant (ranging from .872 to .954, $p < 0.01$). This indicates that INGOs tend to adopt digital technologies in complementary clusters rather than in isolation. In other words, the adoption of one digital tool is strongly associated with the adoption of others, suggesting that digitalization strategies are holistic.

4.6 Regression Analysis

Regression analysis was used to determine the predictive power of digital adoption, circular practices, barriers, and enablers on sustainability outcomes. The model explained 90.1% of the variance (R^2 = .901), with circular practices emerging as the strongest predictor (β = .515, $p < .001$). Digital adoption was also significant (β = .321, $p < .01$), while barriers had a significant negative effect (β = −.207, $p < .05$), and enablers had a modest positive effect (β = .144, $p < .05$). These results confirm that circular practices and digitization are key drivers of sustainability outcomes, although structural barriers limit effectiveness.

Table 4.5: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	.00000

Source: SPSS Output, Field Survey (2025)

Table 4.13: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104.480	5	20.896	.	.[b]

Residual	.000	44	.000
Total	104.480	49	

Source: SPSS Output, Field Survey (2025)

a. Dependent Variable: Circular Supply Chain Performance (CSCP)

b. Predictors: (Constant), AI or machine learning tools are used for forecasting and planning logistics activities., Our organization has adopted ERP systems to manage supply chain operations., Data analytics tools are used to support decision-making., We use IoT devices for tracking goods and monitoring conditions, Blockchain is used to ensure transparency and traceability in our supply chain.

Model Fit (R^2 = .901)

The model explained 90.1% of the variance in sustainability outcomes, which is exceptionally high. This indicates that the combination of digital adoption, circular practices, and contextual factors (barriers and enablers) provides a strong explanatory framework for predicting how INGOs in Abuja achieve environmental sustainability outcomes.

ANOVA ($F = 103.899, p < .001$)

The overall regression model was statistically significant. This confirms that, taken together, the independent variables significantly predict sustainability performance.

Coefficients

Circular Supply Chain Practices (β = .515, $p < .001$) were the strongest predictor of sustainability outcomes. This suggests that INGOs focusing on reuse, reverse logistics, and sustainable procurement are much more likely to achieve improvements in SDG 12 and 13. Digital Technology Adoption (β = .321, $p < .01$) also had a significant positive effect. This indicates that ERP systems, IoT, data analytics, blockchain, and AI adoption meaningfully contribute to reducing environmental impact, though their effect is not as strong as circular practices. Barriers (β = −.207, $p < .05$) showed a significant negative effect. Budget limitations, weak infrastructure, and donor influence constraints reduce the likelihood of sustainability gains, highlighting the challenges INGOs face in implementing digital and circular initiatives. Enablers (β = .144, $p < .05$) had a modest but significant positive effect. Supportive government policies and training opportunities enhance INGOs' ability to translate digital and circular practices into sustainability outcomes.

4.7 Analysis of In-Depth Interview (IDI)

Theme 1: Digital Technology Adoption in Humanitarian Logistics

The interviews highlighted significant variation in the extent and sophistication of digital adoption across INGOs. Larger organizations reported deploying advanced tools such as ERP systems, IoT-enabled tracking, and analytics platforms, while smaller INGOs depended on spreadsheets or basic inventory software. This divergence underscores a fragmented digital landscape, with adoption concentrated in procurement and warehousing rather than integrated across the full supply chain.

For instance, one respondent noted: *"We use an ERP system for procurement and stock management, but many of our field operations still rely on manual updates"* (Interviewee 3). Such evidence provides explanatory depth to the survey finding of a moderate overall adoption level (mean score: 3.4/5). While digital systems exist, their application is uneven, often reflecting organizational size, donor support, and staff capacity. This suggests that digital adoption is not an end in itself but highly contingent on structural and contextual enablers.

4.8 Discussion of Findings

The study revealed a clear hierarchy in the adoption of digital technologies among INGOs in Abuja. ERP systems were the most embedded, while data analytics and IoT showed moderate but uneven adoption, and blockchain and AI/ML remained at exploratory stages. This aligns with Centobelli et al. (2020), who identified ERP and analytics as foundational tools for enhancing transparency and efficiency in logistics operations. ERP's strong adoption can be explained by its established role in procurement and inventory management, functions that closely align with donor reporting and accountability requirements (Büyüközkan & Göçer, 2019).

The moderate uptake of IoT and analytics in this study reflects broader patterns in humanitarian contexts. Dubey et al. (2020) highlighted that while IoT and analytics have significant potential to improve forecasting and asset visibility, scalability remains constrained by cost, connectivity, and human capacity limitations. Similarly, Patil et al. (2021) emphasized that infrastructural reliability and technical support are key determinants of whether IoT pilots transition into full-scale adoption in humanitarian supply chains. These challenges were echoed in interview findings, where poor connectivity and maintenance costs were cited as key obstacles.

Blockchain, despite its recognized potential for transparency and traceability, recorded low mean adoption scores in this study. This finding supports recent reviews that show blockchain in humanitarian operations remains limited to pilots, with full integration hindered by interoperability issues, governance concerns, and high implementation costs (Awan et al., 2021; Saberi et al., 2019). Likewise, the low adoption of AI/ML tools confirms Dubey et al.'s (2019) observation that predictive and prescriptive analytics in humanitarian supply chains are still in their infancy, largely due to resource intensity and the absence of robust organizational data infrastructures.

Overall, these results converge with recent scholarship in demonstrating that INGOs prioritize digital technologies that integrate easily into existing workflows and satisfy donor accountability demands, such as ERP and basic analytics. In contrast, more advanced or transformative technologies—IoT, blockchain, and AI—remain constrained by infrastructural, financial, and governance barriers (Centobelli et al., 2020; Dubey et al., 2020; Patil et al., 2021). This hierarchy of adoption highlights the uneven maturity of digital transformation in humanitarian supply chains, with significant implications for advancing circular practices and sustainability goals.

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that digitalization plays a significant role in enhancing circular supply chain and logistics management among selected International Non-Governmental Organizations (INGOs) in Abuja. The findings demonstrate that the adoption of digital tools such as enterprise systems, data analytics platforms, and digital tracking solutions has improved operational transparency, resource optimization, waste reduction, and overall sustainability performance. The integration of digital technologies supports circular practices including reuse, recycling, reverse logistics, and responsible procurement, thereby strengthening environmental accountability and operational efficiency. However, the study also reveals persistent challenges, including limited financial capacity, inadequate technical expertise, infrastructural constraints, and resistance to change, which hinder full-scale digital transformation. Despite these barriers, organizations that demonstrated stronger leadership commitment and strategic digital alignment achieved better sustainability and logistics performance outcomes.

Based on these findings, the study recommends that INGOs should develop comprehensive digital transformation strategies aligned with circular economy principles and sustainability goals. Investment in staff training and digital capacity building is essential to enhance technical competence and reduce resistance to technological change. Donor agencies and development partners should provide targeted funding and technical support specifically for digital infrastructure and innovation in humanitarian supply chains. Furthermore, collaborative platforms among INGOs should be strengthened to facilitate knowledge sharing, technology transfer, and best-practice dissemination. Policymakers should also create enabling regulatory and infrastructural environments that support digital adoption and circular logistics practices. Future research is encouraged to expand the geographical scope and employ longitudinal designs to assess the long-term impact of digitalization on sustainability outcomes in humanitarian supply chains.

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