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AN ASSESSMENT OF IT TOOLS REQUIRED FOR DIGITAL TRANSFORMATION OF GSCM PROCESSES IN THE NIGERIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Green Supply Chain Management (GSCM) is poised to be instrumental in guiding the construction sector toward more environmentally sustainable practices. As the industry increasingly embraces digital tools to automate supply chain processes, there is a growing necessity to integrate GSCM principles. This shift not only enhances operational efficiency but also aligns with the broader goal of fostering sustainability within construction practices. Hence, this study is aimed at assessing GSCM processes in construction and tools required for digital transformation. To achieve this, a quantitative approach was adopted. A total of 398 questionnaires were sent to construction professionals in Nigeria, through purposive sampling. The data obtained from the survey was analyzed using descriptive statistics, specifically means and percentages. The results revealed "Green construction (4.30) to be the most applied process, followed by Green Procurement (4.26) and Green Design (4.26). The study also revealed the most important tools for digital transformation of the processes in GSCM to be: BIM (4.10), Blockchain technology (3.96) and RFID with IOT sensors (3.86). The study recommends that Organizations should leverage the digital transformation tools that are essential for advancing sustainable practices in the construction industry by optimizing operations and fostering greater accountability throughout the supply chain.

KEYWORDS: *Construction, Digital Transformation, GSCM, IT tools,* Nigeria*, Processes*

INTRODUCTION

Climate change, driven by rising greenhouse gas (GHG) emissions and resource depletion, presents one of the most significant challenges of the twenty-first century (UNEP, 2010). The construction sector is a major contributor to this crisis, accounting for approximately one-third of global carbon emissions, one-third of global resource consumption, 40% of the world's energy consumption, 40% of global waste generated, and 25% of total water consumption (Wang et al. 2022). In response to these environmental challenges, Green Supply Chain Management (GSCM) has been adopted in the construction industry to mitigate these impacts. According to Ali et al. (2023), GSCM streamlines supply chain processes and promotes sustainable practices that significantly reduce the environmental footprint of construction activities.

Digital transformation is revolutionising various industries, with the construction sector at the forefront. As noted by

Samuelson and Stehn (2023), the construction industry faces unique challenges, such as fragmentation and a project-based structure, which necessitate innovative approaches to enhance operational efficiency and sustainability. Lerman et al. (2022) opined that the integration of digital tools into GSCM processes is vital for addressing these challenges, optimising resource utilisation, and minimising environmental impacts. Recent studies underscore the importance of adopting digital procurement platforms, supply chain management software, and IoT technologies to streamline operations (Attaran, 2020; Althabatah et al., 2023; Ikevuje et al., 2024). For example, a report from The Build Chain highlights how contractors like Rasico Construction and THB have successfully leveraged digital procurement platforms to improve material sourcing processes, achieving significant time savings and enhanced project delivery (The Build Chain, 2023). Furthermore, the shift towards digital supply chain management is not solely focused on efficiency; it represents a strategic move towards a more sustainable construction industry that aligns with contemporary environmental goals (Raiden & King, 2021). Several studies have explored the digital transformation of conventional construction supply chains (Wang et al., 2020; Hijazi et al., 2022). Cherian et al. (2021) developed a framework for digital transformation in construction supply chains. However, there remains a gap in comprehensive studies assessing the Information Technology (IT) tools necessary for the digital transformation of GSCM in construction. This will provide construction firms with the knowledge needed to select, implement, and leverage IT tools effectively within GSCM frameworks. This supports transformational change towards more sustainable, efficient, and accountable construction supply chains, which are increasingly demanded by regulators, clients, and society.

Therefore, this study aims to evaluate GSCM processes within the construction industry alongside the tools required for their digital transformation

LITERATURE REVIEW

Concept of GSCM in Construction

Green Supply Chain Management (GSCM) involves managing all activities related to minimizing the environmental impact of an organization's supply chains (Balasubramanian & Shukla, 2017). The goal is to achieve zero net harm to the environment from all the supply chains that contribute to the production of its final products. This approach is aimed at reducing the environmental footprint of companies and promoting sustainability (Goncalves & Silva, 2021; Paletta et al.). GSCM is considered to be the most effective management tool that aims to integrate environmental sustainability thinking into the built environment (Oyefusi et al. 2022).

Several studies, though not all, considered the objectives of GSCM. These were argued to be: increasing the competitive advantage of a firm (Woo et al., 2016), providing stakeholders with added value (Da Rocha et al. (2009), and improving the performance of a supply chain ecologically, economically, and operationally (Balasubramanian & Shukla, 2017).

GSCM Processes in Construction

Green Supply Chain Management (GSCM) integrates environmental factors into traditional Supply Chain Management (SCM) practices, covering the entire lifecycle from design to end-of-life management (Setyaning et al., 2020). Its application in construction spans key supply chain phases: pre-contract, contract, and post-contract (Yevu et al., 2021).

At the pre-contract stage, GSCM emphasizes optimizing processes such as bidding, evaluation, and supplier sourcing to ensure sustainability and compliance with environmental standards. The contract stage targets green logistics and sustainable production of construction materials and components, minimizing environmental impacts during project execution. Post-contract phases focus on ongoing green operations and maintenance (Naniekh et al., 2019).

Several frameworks have been developed to articulate GSCM in construction. For example, Naniekh et al. (2019) propose five core concepts: green initiation, green product design, green material management, green construction, and green operation and maintenance. Wibowo et al. (2018) expand this to include 22 dimensions and 82 elements across these concepts, stressing comprehensive stakeholder involvement and performance measurement. Similarly, Wiguna et al. (2021) highlight the importance of managing hazardous materials, waste reduction, and management support systems (EMS, ISO 14001) as essentials for GSCM implementation.

Badi (2019) offers a systemic view, defining GSCM as a holistic approach to minimize environmental harm while improving competitiveness and stakeholder value, driven by environmental regulations and business efficiency demands. Oyefusi et al. (2024) further extend this by linking GSCM with regenerative supply chain management, emphasizing innovation toward restoration and long-term ecological resilience.

Eco/Green Design

This is of paramount importance for the sector, as decisions made during this stage will significantly influence the life-cycle environmental impact of the building (Balasubramanian & Shukla, 2017; Handayani et al., 2021). Green design in construction supply chain management refers to the integration of environmental considerations throughout the entire supply chain of a construction project, from design and material sourcing to construction and waste management (Albayrak & Ozdemir, 2022; Ding et al., 2021). This approach aims to minimize the construction process's environmental impact and create more sustainable and resource-efficient buildings.

Green Procurement/Purchasing

According to Titus and Brochner (2005), Construction procurement is a key activity within the supply chain associated with the provision of construction works and forms an integral part of supply chain management functions. Procurement as such is an integral part of construction projects and occurs at any point in a project cycle where external resources are required to provide supplies and services in any combination green procurement, also known as environmentally preferable purchasing (EPP), plays a vital role in green supply chain management (GSCM) within the construction industry (Pomponi & Moncaster, 2017). By integrating environmental considerations into the entire purchasing process, construction companies can significantly reduce their environmental impact and promote sustainable practices throughout their supply chains (Zhu et al., 2014).

Green Transportation

According to Oyefusi et al. (2022), Statistics show that transportation alone is responsible for a seventh of greenhouse gas emissions. As a result, the Intergovernmental Panel on Climate Change (IPCC) concludes that transport systems must seek to concurrently enhance mobility, and build resilience to climate change. Furthermore, Woods & Hollnagel (2017) opined that the built environment professionals must seek to design, construct, use, and operate transport infrastructure in a way that optimises operability and resilience in dynamic and unpredictable environments.

Green Construction

In the Project Life Cycle (PLC), green construction is related to the construction phase. However, accomplishment in this stage cannot be separated with previous stages that are planning and design phases (Handayani et al. 2021). The green construction phase plays a crucial role in achieving this goal by focusing on sustainable practices during the construction process itself (Singh & Kumar, 2023). The construction process has negative impact to the environment that relatively smaller than the operational stage, but more intensive. Green construction aims to reduce this negative impact through several steps including material selection, construction waste management, indoor air quality management, energy efficiency, water efficiency, and design for efficiency (BOMA).

End of Life Management

End-of- life management (EOL) in GSCM is basically about maximizing a product's materials' re-use through reverse logistics and circular economy principles (Shen et al., 2022). EOL management and reverse logistics are vital in minimizing environmental impact and maximizing resource recovery. These processes aim to systematically manage construction materials and products at the end of their useful life, preventing them from ending up in landfills and contributing to circular economy principles (Li et al., 2023). To achieve a well regenerated built environment with less resource consumption, Mesa et al. (2020) suggest that reusing, refurbishing, and remanufacturing is advantageous as it preserves the utility and value of building materials.

Table 1 Processes of GSCM in construction

Processes	Author(s)
Eco/Green design	Balasubramanian & Shukla (2017); Handayani et al. (2021); Setyaning et al. (2020); Yevu et al. (2021); Banihashemi et al. (2023)
Green procurement/purchasing	Balasubramanian & Shukla (2017); Handayani et al. (2021); Setyaning et al. 2020; Banihashemi et al. (2023)
Green Construction	Balasubramanian & Shukla (2017); Handayani et al. (2019); Yevu et al., (2021)
End of life management	Balasubramanian & Shukla (2017); Setyaning et al. (2020); Shen et al. (2022)
Green transportation	Oyefusi et al. (2022)
Reverse Logistics	Oyefusi et al. (2022)
Green warehousing	Balasubramanian & Shukla (2017); Setyaning et al. (2020); Shen et al. (2022)
Green recycling	Oyefusi et al. (2022)
Green manufacturing	Balasubramanian & Shukla (2017); Setyaning et al. (2020); Shen et al. (2022)
Green distribution	Oyefusi et al. (2022)

Digital Transformation of GSCM in Construction

Digital technologies are referred to as an advancement in ICT that supports capturing, storing, analysing, communicating, visualizing, incorporating, and collaborating the data (Hamelink, 1997; Whyte and Lobo, 2010). Likewise, Digital technology, according to Froese (2010), is a paradigm shift in the use of developing technologies such as email, BIM, CAD, and Web-Based Project Management (WBPM) software (Cherian &Arun, 2021). The noteworthy effects that digital technologies have had on efficiency and process improvement have made them one of the key enablers of green supply chains (D'Angelo & Belvedere, 2023).

IT tools for Digital Transformation of GSCM in Construction

As technology continues to advance rapidly, construction firms need to adopt digital tools. These tools not only improve decision-making through better visibility and data analytics but also help in building resilience against supply chain disruptions (Lai et al., 2023). This introduction sets the stage for a comprehensive assessment of the IT tools required for digital transformation in GSCM processes within the construction industry, underscoring their potential to drive both operational excellence and sustainable practices. Peretti and Druhmann (2019) opined that today's tools such as Building Information Modeling (BIM) and Life Cycle Assessment (LCA) procedures have the potential to provide information about the material specification, quantities of materials required for construction, and embedded energy of materials. According to Barbosa et al. (2017), the McKinsey Global Institute Report (2017) highlighted low productivity in CSCP and indicated the use of digital technologies for improvements in Construction Supply Chain and Procurement processes (CSCP). Information technology plays a vital role in increasing collaboration among supply chain members. From the information point of view, effective supply chain management must provide the right amount of relevant information to the right person at the right time (Mukaddes et al., 2010).

The digitalization of procurement processes in GSCM can help to improve efficiency, reduce costs, and increase sustainability. The technologies employed in sourcing processes could be used to check the environmental compliance and sustainability performance of contractors/suppliers (Yevu et al. 2021). Research into the utilization of information technology (IT) and tracking technologies in improving construction supply chains, include information systems that capture the status of the order and information about components (e.g., Omar & Ballal, 2009), and tracking technologies to identify the location of components (e.g., Park et al., 2016; Ergen et al., 2011). Using empirical approaches, these studies demonstrate tangible improvements over traditional supply chain management practices in terms of time and money. Some of these studies identified what information to track for different types of components, such as precast concrete members, but not structural steel components. Through Industry 4.0, which focuses on digitization and ubiquitous interactions, new and emerging technologies such as blockchain, smart contracts and Internet of Things (IoT) are being explored for potential applications in CSCP processes (Das, 2024). Digital technologies could be engaged to monitor the transportation plan of products/components to ensure environmental compliance. The post-contract stage focuses on the aftermath of products delivered/in- stalled for replacement or reuse management. Other initiatives such as reverse logistics could be employed in Digital Supply Chain and Procurement technologies at this stage (Yevu et al., 2021).

Studies have reported that the use of these emerging technologies regarding construction supply chain and procurement functions at various stages in the supply chain is limited (Das, 2024). Specifically, how these technologies enhance sustainable processes in processes are scarce (Yevu et al. 2021). Several authors have argued that adopting a digitalized solution could help to overcome the issue and will contribute to the success of the CSC by changing the business model from a scaled deliverable only to a digital deliverable for construction, operation, and asset management (Getuli et al. 2016; Gould et al. 2010; Pryke, 2009).
Extant literature has shown that the information technologies that are essential for the digitalization of procurement processes in GSCM include:

1. Electronic procurement (e-procurement) systems: These systems automate the procurement process, enabling suppliers to submit bids electronically and allowing buyers to evaluate and select bids online. According to Li et al. (2021), e-procurement systems can reduce procurement costs by up to 30%.

2. Cloud computing: Cloud computing provides a platform for storing and accessing procurement data and documents online. This enables stakeholders to access procurement information from anywhere at any time, improving collaboration and transparency in procurement processes (Yevu et al. 2021).

3. Big data analytics: The use of big data analytics can help to identify patterns and trends in procurement data, enabling stakeholders to make informed decisions and optimize procurement processes. For instance, big data analytics can be used to identify suppliers with the lowest environmental impact (Chen, 2024).

4. Radio Frequency Identification (RFID) and Internet of Things (IoT): RFID technology enables the tracking of goods and materials throughout the supply chain, providing real-time visibility and improving inventory management. This can help to reduce waste and improve sustainability in procurement processes (Mishra & Khoteja, 2024). Liu et al. (2020) proposed an RFID-based management model to inspect all the steps in a precast supply chain, including the materials, production, logistics, and delivery activities. In other studies, information tracking technologies such as barcodes and RFID have been proven to enable the recording of real-time information on PCs, thereby reducing inventories and supply chain costs (Wang et al., 2020).

5. Blockchain: Blockchain technology provides a secure and transparent platform for recording and tracking procurement transactions. This can help to reduce fraud and corruption in procurement processes, while also improving transparency and accountability (Chen et al., 2020). According to Hijazi et al. (2021), Blockchain technology is on a path to disrupt many aspects of businesses that deal with the coordination of information and trust to enable a single source of truth model with multiple control entities.

6. Artificial intelligence (AI): AI can be used to automate repetitive procurement tasks, such as data entry and analysis. This can help to improve efficiency and reduce errors in procurement processes (Mishra et al., 2019).

7. Building Information Modelling (BIM): BIM plays a key role globally in enabling the digitalization of design and related workflow in the construction industry (Kinnaird and Geipel, 2017; Li et al., 2022; Mason, 2019; Hijazi et al., 2021). BIM helps the CSC stakeholders to be well-informed of one another's activities through collaboration (Deng et al. 2019). BIM technology is helpful to construction supply chain management. The application of BIM technology can provide a reliable platform for the information interaction of the construction supply chain, promote the level of information management, and then improve the overall cooperation level of the supply chain.

RESEARCH METHOD

The research problem and data required for the study made it necessary to adopt a Quantitative research approach, which involves collecting and analyzing purely numerical data. The target population for this study comprises construction professionals in Nigeria, which, according to their respective professional bodies, presently stands at 6132 Architects, 77460 Engineers, 5172 Quantity Surveyors, and 3756 Builders as obtained from ARCOM, COREN, QSRBN, and CORBON, respectively. These professionals were selected using a purposive sampling technique, targeting the construction professionals with knowledge in the subject area. The sample size was determined using Yamane's formula (1967), a statistical formula, which calculated the sample size;

$= N/1+N(e)^2$ where n =sample sizeN = total population e=Margin of error $(10\%)^2$;

$$n = \frac{92520}{1+92520(10\%)^2}$$

$$n = 92520/1 + 9250(0.01)$$

$$n = 398$$

The sample size of 398 participants was determined based on the total population surveyed. Data was collected using a self-administered questionnaire consisting of three sections: A, B, and C. Section A gathered demographic information about the respondents, including details such as the type of organization, academic qualifications, and professional experience. Section B assessed participants' levels of agreement with the execution of processes in Green construction projects. A Likert scale ranging from 1 to 5 was used for this purpose, where 1 indicates "Strongly Disagree," 2 indicates "Disagree," 3 indicates "Neutral," 4 indicates "Agree," and 5 indicates "Strongly Agree." This ranking scale is a commonly used format for obtaining feedback from respondents regarding an object, event, or attribute.

RESULTS AND DISCUSSION

This section presents the findings from the assessment of the IT tools essential for driving digital transformation within the GSCM processes at the NCI. It encompasses a thorough analysis of both the processes and the technological tools, providing deep insights into their functionalities, implications, and the discussions surrounding them.

Reliability Analysis

Table 2 presents the results of the validity and reliability of the survey instrument, which provides important insights into the robustness of the measurement tool used in the study. The Cronbach's Alpha obtained is 0.974, which indicates an excellent level of internal consistency among the items in the questionnaire. This high alpha value suggests that the items are measuring the same underlying construct effectively and are yielding reliable scores. Generally, a Cronbach's Alpha of 0.7 or higher is considered acceptable, so a value of 0.974 significantly exceeds that threshold and adds confidence to the reliability of the questionnaire. Additionally, the Cronbach's Alpha Based on Standardized Items is reported at 0.970. This metric adjusts for the different variances of the items and provides a slight variation of the original alpha. The closeness of these two values implies that the standardization process did not significantly affect the consistency of the items, further reinforcing the reliability of the questionnaire. The number of items included in the questionnaire is 17, a high item count typically allows for a more comprehensive assessment of the construct being measured, as long as the items maintain relevance and coherence.

These results suggest that the questionnaire is both valid and reliable, making it a suitable tool the study as such strong reliability statistics contribute to the credibility of the data collected through the questionnaire and enhance confidence in the findings derived from it.

Table 2: Reliability Statistics of the Instrument

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.974	0.974	17

Survey Response Rate

The quantitative data collected for this research was thoroughly analyzed and interpreted using the statistical software IBM SPSS (Statistical Package for the Social Sciences), version 27. This program facilitated the tabulation of data and the generation of descriptive statistics, including frequencies, percentages, and standard deviations. Responses were ranked according to their relative importance, enabling a clear understanding of the data's implications. Out of 398 questionnaires distributed, a response rate of 48% was achieved, which is deemed sufficient for robust analysis. Moser and Kalton (1971) indicate that response rates below 30-40% may lead to biased and unreliable results. Therefore, the response rate obtained in this study is considered adequate for drawing meaningful insights and ensuring the validity of the findings.

Characteristics of Surveyed Respondents

Table 3 shows that the respondents come from various professional disciplines, with quantity surveyors being the largest group at 29.8%, followed by architects at 23.3%. In terms of experience in green-compliant construction projects, the majority of respondents have more than 5 years of experience (34.0%) and 6 to 10 years of experience (31.9%). When it comes to educational qualifications, the most common qualification among the respondents is a BSc. at 45.6%, followed by MSc. at 39.0%. Lastly, the type of projects the respondents are involved in is mainly residential (53.2%) and commercial (23.4%), with smaller percentages in industrial and infrastructure projects. The findings from Table 4.3 indicate a strong presence of experienced professionals in green-compliant construction, especially among quantity surveyors and architects. With over half of respondents having more than five years of experience and a high percentage holding BSc or MSc degrees, it suggests a knowledgeable workforce driving sustainability in residential and commercial projects. This trend reflects an increasing demand for eco-friendly spaces and highlights the potential for continued advancements in green building practices.

Table 3: Characteristics of surveyed respondents

	Characteristics of Surveyed Respondents	Responses
1	Professional Discipline of Respondents	Architects (23.3%, Quantity Surveyors 29.8%, Engineers (14.8%), Builders (13.0%)
2	Respondent's Experience in Green Compliant Construction Projects	>5yrs (34.0%), 6-10yrs (31.9%), 11-15yrs (23.4%), 16-20 (6.4%), and over 20yrs (2.0%)
3	Educational Qualification	HnD (5.10%), BSc. (45.6%), MSc (39.0%), PhD. (8.90%)
4	Type of Project	Residential (53.2%), Commercial (23.4%), Industrial (2.1%), Infrastructure (21.3%)

Assessment of Processes in GSCM in Construction

Table 4 presents the results from the assessment of Green Supply Chain Management (GSCM) processes. The respondents were asked to select the processes that were applied in the Green-compliant construction projects they had participated in using a scale of 1-5, where 1 indicates Strongly Disagree and 5 indicates Strongly Agree. From the result 'Green construction' (Mean: 4.30, Rank: 1st) emerged as the most applied process, indicating a strong recognition among stakeholders of its critical role in promoting sustainability. The low standard deviation (0.507) indicates a consensus among respondents on its importance. Closely following green construction, "green procurement and purchasing processes (Mean: 4.26, Rank: 2nd) are also highly regarded. This reflects an understanding that sourcing sustainable materials and selecting environmentally responsible suppliers are essential for achieving overall sustainability goals. The standard deviation of 0.488 further confirms a strong agreement on its significance.

Eco/Green Design (Mean: 4.26, Rank: 3rd) shares the same mean score as green procurement but ranks third due to a slightly higher standard deviation (0.570). This indicates that while eco-design is recognized as important, there may be varying opinions about its implementation and effectiveness in different contexts. "Green Recycling" ranked 8th, With a mean score of 2.87, green recycling is perceived as less critical relative to other processes in GSCM. This finding highlights potential gaps in awareness or implementation strategies for recycling initiatives within the construction sector). Green manufacturing ranks 9th with a mean score of 2.38, indicating that it is not viewed as a priority within the context of GSCM in construction processes by respondents. this suggests significant room for improvement and a greater focus on sustainable manufacturing practices. Finally, "Green distribution" received the lowest mean score of 2.32, suggesting it is the least emphasized area among GSCM processes assessed in this study. This may point to a lack of awareness or implementation challenges related to the sustainable distribution method.

The assessment of the GSCM processes reveals a strong commient to sustainability in construction, with "Green construction," "green procurement," and "Eco/Green Design" receiving high mean scores, indicating their recognized importance. However, lower scores for "Green

Recycling," "Green manufacturing," and "Green distribution" highlight significant gaps in awareness and implementation. This suggests that while key processes are prioritized, more focus is needed on recycling, sustainable manufacturing, and distribution to enhance overall sustainability in the industry. The findings align well with previous studies (Handayani et al., 2021; Oyefusi et al., 2022) emphasizing the centrality of these processes in achieving sustainability in construction. Balasubramanian and Shukla (2017) similarly highlighted green construction and sustainable procurement as foundational for environmental performance, noting their influence on reducing material waste and promoting resource efficiency. Handayani et al. (2021) reinforce this prioritization by identifying green design as critical for embedding sustainability principles early in project lifecycles, which supports the recognition of eco-design in this current study. Setyaning et al. (2020) also emphasize the role of green procurement in selecting environmentally responsible suppliers, echoing the strong stakeholder consensus observed here.

However, the relatively low ranking and mean scores for “Green Recycling” (2.87), “Green Manufacturing” (2.38), and “Green Distribution” (2.32) reflect persistent challenges noted in prior research. Banihashemi et al. (2023) report gaps in recycling initiatives due to technological and logistical constraints, paralleling this study’s finding that recycling is less embraced in construction supply chains. Similarly, Oyefusi et al. (2022) point to sustainable manufacturing and distribution as underdeveloped areas requiring greater strategic focus and innovation to close sustainability gaps.

Table 4: Assessment of GSCM in construction processes

GSCM Processes	Mean	Std. Deviation	Rank
Green construction	4.30	0.507	1st
Green procurement/purchasing	4.26	0.488	2nd
Eco/Green design	4.26	0.570	3rd
End-of-life management	4.00	0.552	4th
Green Transportation	3.85	0.691	5th
Reverse Logistics	3.66	0.668	6th
Green warehousing	3.17	0.732	7th
Green recycling	2.87	0.824	8th
Green Manufacturing	2.38	0.874	9th
Green Distribution	2.32	0.810	10th

Assessment of Digital Tools for Transformation of GSCM Processes

Table 5 presents the results of the assessment of digital transformation tools for GSCM processes. The findings indicate that Building Information Modelling (BIM) holds the highest rank with a mean score of 4.10, making it the most valued tool. This emphasizes BIM's critical role in improving collaboration, visualization, and efficiency throughout the construction lifecycle. Blockchain technology ranked second, noted for its ability to enhance transparency and traceability within the supply chain, earning a mean score of 3.96. It is recognized as an essential tool for ensuring data integrity and facilitating secure transactions. Its applications in procurement processes, including smart contracts and supplier management, further highlight its significance in GSCM.

Ranked third, RFID with IoT sensors achieved a mean score of 3.86. The integration of Radio-Frequency Identification (RFID) with the Internet of Things (IoT) showcases strong recognition of its capabilities for real-time tracking and inventory management. This technology improves visibility across the supply chain, enabling better decision-making and resource allocation.

Although still important, big data analytics received a lower mean score of 3.37 compared to the other tools, suggesting it may not yet be fully utilized in GSCM practices. Nevertheless, its potential for generating insights from large datasets remains significant as organizations increasingly pursue data-driven decision-making. These findings underscore Building Information Modelling (BIM) as the leading digital transformation tool for GSCM processes. This result aligns with earlier studies by Pryke (2009) and Yevu et al. (2021), who highlighted BIM's role in enhancing design collaboration, project visualization, and lifecycle management. Pryke specifically recognized BIM as a foundation for improved communication among project stakeholders, which is supported by the current study's high mean score of 4.10.

The importance of blockchain technology aligns with the work of Das (2024) and Getuli et al. (2016), both of whom identified blockchain as crucial for enhancing supply chain transparency, traceability, and security. Das's recent research further expands blockchain's application to smart contracts and supplier compliance, reinforcing its vital function in modern procurement and GSCM frameworks. The adoption of RFID integrated with IoT sensors, ranked third, reflects findings by Gould et al. (2010) who recognized RFID as a powerful tool for real-time inventory tracking and supply chain visibility. The integration of IoT enhances this capability by enabling dynamic data flows and improved resource management across complex construction supply chains.

Big data analytics received a comparatively lower score (3.37), consistent with the findings of Yevu et al. (2021) and Gould et al. (2010), who acknowledged big data's potential but noted that it is underutilized in current GSCM practices. Despite this lower rating, the ability of big data to extract actionable insights from extensive datasets remains crucial as organizations advance their digital strategies.

Table 5: Assessment of Digital Tools for Transformation of GSCM Processes

Digital Transformation Tools	Mean	Std. Deviation	Rank
Building Information Modelling (BIM)	4.10	0.507	1st
Blockchain Technology	3.96	0.488	2nd
RFID with IOT sensors	3.86	0.570	3rd
Artificial Intelligence	3.84	0.552	4th
Electronic Procurement Systems	3.80	0.691	5th
Cloud Computing	3.66	0.668	6th
Big Data Analytics	3.37	0.732	7th

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study was aimed at assessing GSCM processes and the tools required for digital transformation. The results reveal that the most applied processes in GSCM are Green Construction (4.30), Green Procurement (4.26) and Green Design (4.26). The study also revealed the most important tools for digital transformation of the processes in GSCM to be: BIM (4.10), Blockchain technology (3.96) and RFID with IOT sensors (3.86). The assessment of GSCM in construction processes clearly indicates that stakeholders in the construction industry prioritize green construction and procurement practices while recognizing the importance of eco-design and end-of-life management strategies. The findings indicate that Building Information Modelling (BIM) is the most crucial digital transformation tool for GSCM processes, followed closely by blockchain technology and RFID with IoT sensors. These tools are recognized for their roles in enhancing efficiency, transparency, and collaboration within supply chains. However, there is an opportunity to improve the adoption and application of big data analytics within GSCM practices to fully harness its potential benefits.

Recommendations

Overall, the study recommends that organizations should focus on enhancing their understanding and implementation of GSCM processes to achieve comprehensive sustainability goals within their operations. By addressing these gaps and promoting awareness around all aspects of GSCM, the construction sector can further advance its commitment to environmental stewardship and sustainable practices. Organizations should leverage the digital transformation tools that are essential for advancing sustainable practices in the construction industry by optimizing operations and fostering greater accountability throughout the supply chain. Future studies in this area should align the identified IT tools with the specific GSCM processes they can digitize to fully leverage the findings of this study.

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