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Assessment of Construction Sites Sustainable Waste Management Strategies in Abuja

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Abstract

Waste management and sustainability are two fundamental underlying ideas that the construction industry must recognise and execute. Nevertheless, doing so may be difficult and time-consuming. To this end, the aim of this study is to assess sustainable waste management strategies adopted at construction sites in Abuja with the view to enhancing material waste sustainability practises adopted by construction firms on construction sites. The study adopted a quantitative research approach with the use of a structured questionnaire, administered to 155 respondents. Of the 155 questionnaire copies administered, 150 copies were returned and used for data analysis, giving a response rate of 97%. The analysis of the data was carried out with the use of percentage, mean item score (MIS), and factor analysis. The study identified six (6) factors affecting the management of material waste on construction sites, of which financial factors (MIS = 4.08) are the most significant factors. Material costs and energy costs were the most important social sustainability factors (MS = 3.80 and 3.80) respectively. Re-imagine and re-design were identified as the most significant strategies (MS = 4.50). The recycling strategy was identified as the most effective strategy (MS = 4.70). The KMO value is 0.655, and the Bartlett's test of sphericity is significant ($p < 0.05$). However, it is, therefore, that the adoption of a sustainable building construction waste management process will minimise, reuse, and recycle construction waste to the greatest extent possible to alleviate the construction waste issue in Abuja and Nigeria at large. The major recommendation from the study was that for waste management to be sustainable in the Nigerian *construction sector, an upgrade in either the approach or method of application is required.*

Keywords: Construction Sites, Sustainable, Waste Management, Strategies

Introduction

The construction industry has long enjoyed immense benefits for its significant contribution to materializing the built environment, creating job opportunities, and maintaining economic growth (Lee *et al.*, 2020). However, with the increasing embracement of sustainability globally, a surge of criticism has been overtly targeted at construction, which is perceived as the culprit of environmental degradation, non-renewable natural resources consumption, gas and dust emission, solid waste generation, noise pollution, as well as land depletion and deterioration (Lu *et al.*, 2016; Yang *et al.*, 2019, 2020). Particularly, significant attention has been paid to Construction waste in recent years, discerning it a pivot to indicate the degree of sustainability (Yang *et al.*, 2019).

Material waste according to Lu et al., (2019); Wu et al., (2019); Chi et al., (2020) simply means the solid waste arising from construction, demolition and renovation projects. It often comprises surplus materials from excavation, site clearance, construction, demolition, renovation, refurbishment, and road works (HKEPD, 2015). The classification of Material waste varies with territorial contexts (HKEPD, 2019). Material waste can also be classified into either inert or non-inert, depending on whether it has stable chemical properties or not (HKEPD, 2019). Inert materials include earth, soil, rocks, slurry, and broken concrete, while non-inert waste includes predominantly organic materials, such as packaging waste, bamboo, timber, and vegetation (HKEPD, 2015).

According to Lu et al., (2017) material waste in major economies accounts for about one quarter of the total amount of solid waste being landfilled. Given the non-trivial volume and its adverse impacts, researchers and practitioners have spared no effort in managing the waste. Various measures have been devised. These measures can be summarized by the “3R” principle, i.e., Reduce, Reuse, and Recycling (Lee et al., 2020). Through recycling, construction waste can be turned into new resources for use, such as recycled aggregates and bricks. Regardless of how well reduction and reuse are being conducted, certain amount of material waste will inevitably be generated. Under this circumstance, recycling is the final option before proceeding with disposal as a last resort.

According to Ameh and Itodo (2013), most Nigerian construction industry executives pay little attention to the impact of produced material waste on project cost overruns. Material waste accounts for about 30-35 percent of most project construction costs, and construction materials lost on site account for approximately 9% of the procured materials by weight (Memon, 2013). Nowadays, it is appropriate to take on concepts of sustainable material waste management to avert the probable harmful effects associated with such waste in terms of the economic, environmental and wellbeing dimensions (Nagapan et al., 2012). Therefore, a viable and clear strategy is necessary to achieve adequate management of construction sites material waste in Abuja. This paper aims to assess sustainable waste management strategies adopted at construction sites in Abuja with a view to enhance material waste sustainability practices adopted by construction firms on construction sites.

LITERATURE REVIEW

Construction materials significantly contribute to the total cost of construction, and the wastage of these materials will negatively impact on the contractors profit, construction cost and duration, and can cause dispute among key project participants *(*Adewuyi *et al., 2020)*. Akinkurolere and Franklin (2005) carried out an Investigation into Waste Management on Construction Sites in South Western Nigeria. The study focused on the dangers posed by material waste in the construction industry, ways of minimizing construction waste, ways of keeping proper site records for accountability sake. And recommend effective waste management measures. This research adopted questionnaires to collect data from construction professionals, and employed tables and statistical indices for the data analysis. The study revealed that material wastage increase the cost of construction project and reduce contractor's profit. And attributed construction was to poor management and lack of effective waste management awareness. The study recommended that construction waste management should be recycled and reused. And through giving incentives to workers for proper handling, material wastage is reduced; and trained personnel should be used as supervisors.

Sasidharani and Jayanthi (2015) carried out a study on Material Waste Management In Construction Industries of India. The stud investigated the cause of waste, waste prevention method and the wastage level in construction site. The study adopted a questionnaire survey. Questionnaires were administered to construction professionals. The study adopted weighted average and coefficient of variation criteria and T-test statistical technique of comparing means. The study reported that Design Changes during construction, weak material management, poor site storage facilities, errors by tradesmen and severe weather conditions were the major factors affecting waste generation. Adequate storage of material is one of the major minimization measures.

The study recommended a holistic and analytical approach to construction waste management problems.

Adewuyi, and Odesola, (2015), studied Factors Affecting Material Waste on Construction Sites in Nigeria. Their study assessed the level of contribution of several factors to construction material waste generation; and used structured questionnaires which were administered to two groups of stakeholders (consultants and contractors) in construction industry. These two groups of stakeholders are construction professionals. They used Relative contribution index, Mann Whitney U and Kruskal-Wallis tests was used to analyze the collected data. They found that the highest contributors to materials waste are reworks due to non-conformance to specifications, waste from cutting uneconomical shapes, and design changes and revisions. Also, location of site has no effect in the level of contribution of the assessed factors to material waste generation. And they concluded that material waste generation is a critical and complex issue in Nigerian construction industry.

Adafin *et al.* (2010), researched on Material Control Strategies in Some Selected Construction Firms in Nigeria. The purpose of the study was to assess the various strategies utilized by building construction firms for controlling materials on construction sites. Also, to identify the stages of in the course of the project execution in which adequate material control adopted; to assess the impact of building construction firms‟ adherence to standard material control strategies on building project performance and delivery. They used well-structured questionnaire administered to construction professionals to collect data. They found out that recognition of material control practice and implementation of the strategies involved by building construction firms would ensure timely project execution and standard work delivery within reasonable cost, time and quality.

RESEARCH METHODOLOGY

A quantitative research approach was adopted in this study. The study population for this research was determined using the number of construction companies registered with the Abuja Business Directory in Abuja and functioning within the city. According to the Abuja Business Directory (2021), there are 255 construction companies listed in the Abuja Business Directory with Abuja as their registered address. The population for the study is made up of construction firms adopting construction waste strategies for construction projects. For the purpose of this study construction firms adopting material waste management were selected because provided more accurate information for the study. The sample size for the study was 155, based on the Krejcie and Morgan (1970) Table. On Krejcie and Morgan's (1970) table, the representative sample size for a population of 255 is 155. Since the population size of 260 is the nearest number to 255 on the Krejcie and Morgan (1970) Table shown in appendix A, then the sample size for this population size (155) was adopted for this study. The sample for this study was made up of The use of structured questionnaires was employed for data collection in order to achieve the study's objectives. The questionnaire (designed in a five-point Likert scale format) addressed issues relating to the research objectives respectively. The collected data was analysed using the Mean Item Score (MIS) and factor analysis.

RESULTS AND DISCUSSION

Factors Affecting Management of Material Waste on Construction Sites

The factors affecting the management of material waste on construction sites were gauged through the use of Mean Score analysis. In line with Guerrero *et al.* (2013), factors affecting construction waste management barriers and motivations for construction waste were grouped around six different aspects: financial, institutional, environmental, socio-cultural, technical, and legal.

The results of the analysis revealed that construction professionals agreed that (i) financial (MIS = 4.08) and (ii) institutional (MIS = 3.08), which were ranked 1st and 2nd as the most important factors affecting the management of material waste on construction sites, respectively. Conversely, the least known factors affecting management of material waste on construction sites were (a) technical and (b) socio-cultural, which were ranked 5th and 6th. It was observed that the general agreement was not very high; all six factors had a mean score (MS) ranging between 4.08 and 3.40. This range lay between 4.50 and 3.50, which corresponded to a "Moderate Extent" of awareness. The findings of the study are in support of the findings of Yuan *et al.* (2011), where it is suggested that financial obstacles are related to the absence of markets receiving recycled construction products, which jeopardise efforts for construction waste recycling or minimization practises.

Table 1: Factors Affecting Management of Material Waste on Construction Sites

Factors Affecting Management of Material Waste on Construction Sites	*Mean Score*	*Rank*
Financial	4.08	1
Institutional	3.80	2
Environmental	3.52	3
Legal	3.48	3
Technical	3.44	5
Socio-Cultural	3.40	6
Average MIS	3.62	

Material Waste Management Strategies Adopted in Construction Projects
This section of the study reports the results of analysis carried out in pursuance of examination of material waste management strategies adopted in construction projects. It was also gauged through the use of mean score analysis.

Material waste management strategies

Material waste management strategies were ranked from 1st to 6th; re-imagine and re-design were identified as the most significant strategies (MS = 4.50, ranked 1st). Recovery (ranked 6th, MS = 4.08) was the least significant strategy. The average level of significance of these material waste management strategies was relatively high (MS = 3.90); this corresponds to "very significant" material waste management strategies. As shown in Table 2.

Table 2 : Material waste management strategies

Material waste management strategies	*Mean Score*	*Rank*
Re-imagine and Re-design	4.52	1
Reduce Strategy	4.48	1
Reuse Strategy	4.36	3
Recycle Strategy	4.18	3
Disposal	4.12	5
Recovery	4.08	6
Overall	4.29	

Impact of material waste management strategies on sustainability of construction projects
This section of the study reports the results of an analysis carried out in pursuance of determination of the impact of material waste management strategies on the sustainability of construction projects. It was also gauged through the use of mean score analysis.

Impact of material waste management strategies

Table 3 showed that the impact of material waste management strategies was ranked from 1st to 6th; the recycle strategy was identified to be the most effective strategy (MS = 4.70, ranked 1st). Recovery (ranked 6th, Ms = 4.28) was the least effective strategy. The average level of effectiveness of these impacts of material waste management strategies was relatively high (MS = 4.41); this corresponds to the "very effective" impact of material waste management strategies. In line with this study, several authors identified reuse and recycling strategies as the popular mechanisms of waste minimisation (Banias *et al.*, 2011; Coelho & de Brito, 2011; Tam, 2011;

Udawatta *et al.*, 2015). In addition, there are studies that indirectly encourage the incorporation of the reduce strategy, such as introducing the charging scheme and shifting the mindsets and attitudes of the top management and workers towards better waste management (Lu & Yuan, 2011; Yu *et al.,* 2013).

Table 3: Impact of material waste management strategies

Impact of material waste management strategies	*Mean Score*	*Rank*
Recycle Strategy	4.70	1
Reuse Strategy	4.44	1
Reduce Strategy	4.38	3
Re-imagine and Re-design	4.34	3
Disposal	4.32	5
Recovery	4.28	6
Overall	4.41	

Factor Analysis for Factors that Affecting Management of Material Waste on Construction Sites

In Table 4, the KMO value is 0.655 and the Bartlett's test of sphericity is significant (p 0.05). The results of the reliability test, correlation matrix, Kaiser–Meyer–Olkin measure of sampling adequacy (KMO), and Bartlett's test of sphericity show that the data obtained is reliable and sufficient to conduct a factor analysis.

Table 4 KMO And Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.655
Bartlett's Test of Sphericity	Approx. Chi-Square	249.694
	df	15
	Sig.	.000

The results of the principal component analysis are shown in Table 5 and the Scree plot (Figure 1). Based on Kaiser's criterion, two components were extracted for having eigenvalues above 1.0 (2.571 and 1.413). Component 1, with an eigenvalue of 2.571, accounts for 42.85% of the variance in the dataset. While component 2, with an eigenvalue of 1.413, accounts for 23.55% of the variance, Subsequently, all the two components account for 66.40% of the variation in the factors that affect the management of material waste on construction sites. Referring to the Cattell's scree plot in Figure 1, there are seven components above the point where the curve changes direction and becomes horizontal. These two components should therefore be retained.

This further confirms the result in Table 5, where two components with eigenvalues greater than one were extracted based on Kaiser's criterion.

Table 5 Total Variance Explained

Component	*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*			*Rotation Sums of Squared Loadings*		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.571	42.849	42.849	2.571	42.849	42.849	2.148	35.807	35.807
2	1.413	23.552	66.402	1.413	23.552	66.402	1.836	30.595	66.402
3	.811	13.520	79.922						
4	.470	7.839	87.761						
5	.431	7.189	94.950						
6	.303	5.050	100.000						

Extraction Method: Principal Component Analysis.

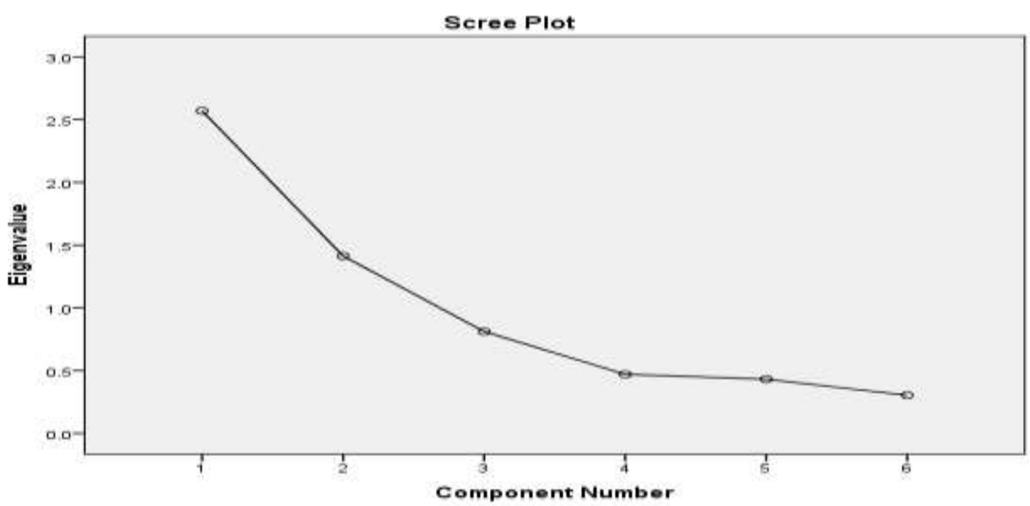

Figure 1: Scree plot of the Components

Kaiser's criterion and Cattell's scree test were used to determine the two factors to retain. Factor rotation based on the Varimax Orthogonal rotational technique was employed to reveal the pattern of loadings in a way that would be easier to explain. Following previous studies by Pallant (2005) and Kuma et al. (2018), factors with absolute values of less than 0.3 correlation loadings were sorted by size and suppressed to make the output easier to explain. The results of each of the two extracted components and their variables are shown in Table 6.

Table 6 Rotated Component Matrix[a]

Rotated Component Matrixa	*Component*	
	1	2
Technical	.832	
Socio-Cultural	.826	
Legal	.764	
Financial		.874
Environmental		.717
Institutional	.401	.715

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

From Table 6, two components are extracted as factors that affect the management of material waste on construction sites: The first component has significant correlation loadings for a group of four variables, namely: technical, socio-cultural, legal, and institutional. These variables are based on previous studies. The second component has significant correlation loadings for a group of three variables, namely financial, environmental, and institutional.

CONCLUSION AND RECOMMENDATION

The construction industry has been found to be a major generator of waste, and there are many challenges associated with finding the most sustainable ways to manage construction waste. In view of this, the study assessed construction sites' sustainable waste management strategies in Abuja.. The results of the analysis carried out led to the conclusions made in this chapter.

The most significant factors are: Financial factors were identified as factors affecting the management of material waste on construction sites. The least significant factors affecting the management of material waste on construction sites are socio-cultural. Re-imagine and re-design were identified as the most significant strategies. Recovery was the least significant strategy. The recycling strategy was identified as the most effective strategy. Recovery was the least effective strategy. Finally, The results of the reliability test, correlation matrix, Kaiser–Meyer–Olkin measure of sampling adequacy (KMO), and Bartlett's test of sphericity show that the data obtained is reliable and sufficient to conduct a factor analysis. It can therefore be concluded that the adoption of a sustainable building construction waste management process will maximally alleviate the construction waste situation by way of reducing, reusing, and recycling the construction waste in Abuja and Nigeria at large.

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