*Article*

# Contemporary Issues in Construction Wastes Management in Abuja Federal Capital Territory, Nigeria

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**Nuhu Daura[1], Rabiu Muhammed [2]***

[1] NNPC Upstream Investment Management Services (NUIMS) No. 36 Gerrard Road, Ikoyi, Eti-Osa. Lagos.
[2] Geography Department, University of Abuja, Nigeria. E-mail: rabiu.muhammed@uniabuja.edu.ng
* rabiu.muhammed@uniabuja.edu.ng

***Abstract***

*Construction waste poses significant environmental, social, and economic challenges to sustainable development globally. This study examined the contemporary issues in construction waste management in Abuja Federal Capital Territory, Nigeria, with emphasis on types, volume, and management practices of construction and demolition wastes. A mixed-methods design was employed, drawing data from both primary sources; questionnaire, interviews, and field observations and secondary records from construction firms and the Abuja Environmental Protection Board. Seven major construction companies were purposively selected, and 382 professionals were sampled. Descriptive and inferential statistical tools, including ANOVA, Z-score, and Principal Component Analysis, were used for data analysis. Findings revealed that mixed sand, concrete, bricks/blocks, and wood are the most prevalent waste types, while average annual waste generation between 2000 and 2022 showed a declining trend. Material reuse on-site, on-time delivery, and avoidance of over-ordering were the most common waste-management strategies, whereas energy recovery and recycling were rarely practiced. Principal Component Analysis identified three main constraints; environmental negligence (32.93%), knowledge gaps (30.58%), and cost factors (21.58%) explaining 85.09% of management challenges. The study concludes that sustainable waste management in Abuja's construction sector requires enhanced environmental awareness, technical training, and economic incentives to promote circular economy practices.*

**Keywords:** Construction waste, Efficiency, Waste volume.

## 1. Introduction

Construction waste is one of the contemporary societal challenges attracting increasing attention globally. Construction and Demolition (C&D) waste is derived from the construction, renovation or demolition process that is no longer viable for use (Purchase, Zulayq, O'Brien, Kowalewski, Berenjian, Tarighaleslami and Seifan, 2021). Construction waste has environmental, societal and economic implications and therefore Construction and Demolition waste encompasses three pillars of sustainability. Consequently, waste management is central to sustainable construction. Sustainability in construction is all about following best practices that consider the environmental, economic and social impacts of construction activities. It involves being rational in the choice of materials, methodologies as well as design philosophy to ensure environmentally friendly, economic efficiency and socially inclusive (Surajo, Danjuma, Mahmud and Abugu, 2019).

Sustainable management of construction waste follows the pathways of circular economy and green development. Circular economy approaches include reuse, reduce, repair and recycling (4Rs) of waste materials (Ogunmakinde, 2019). Green development in construction is environmentally conscious planning, implementation and use of construction projects (Patel and Patel, 2021). It is vital and urgent to integrate sustainability into the construction industry, thus, experts and policy-makers are consistently devising strategies, policies and practices to ensure integration (Maqbool, Saiba, Altuwaim, Rashid and Ashfaq, 2022). Transitions to more sustainable construction are essential in combating so many global challenges such as climate change, housing deficit, energy crisis, pollution from waste, deforestation and others. Studies have shown that the right approach to engage in sustainable construction is to improve efficiency and bring productivity in the utilization of resources (Emuze and Saurin, 2015; Awad, Guardiola and Fraíz, 2021).

Construction is healthier, when raw materials are stored longer in the production cycle and can be recycled, thus producing less or zero waste (Picart and Rauf, 2021). This is why the concepts of sustainability and zero waste are gaining the attention of the construction sector worldwide. There are some policies and legislation enacted to promote sustainable construction which include construction waste disposal charging schemes, pay-as-you-throw schemes, stepwise incentive systems, landfill bans, and extended producer responsibility (Ogunmakinde, 2019). These policies and legislations cannot meet the sustainable requirements of firms as they focused more on managing waste after it has been generated, rather than preventing and minimizing the waste generation at each stage of construction. The need for a sustainable approach to waste minimisation has been emphasised in the literature but has not been comprehensively adopted.

It has been portrayed that current construction methods are based on a linear economy model that 'takes-makes-uses-disposes' (Jackson, Lederwasch and Giurco, 2014). This implies that Natural resources are extracted (i.e. 'take') to manufacture (i.e. 'make') products (i.e. 'use') and thereafter disposed of. The consequences of such practices include land intake for landfill, pollution, waste of resources, and increase economic and environmental costs (Akinpelu, 2007; Zhang, Zheng, Duan, Yin, Li, and Niu, 2019). If materials are disposed of either during the construction process or at the time of demolition, the raw materials are not recovered and it is beg loss (Ellen MacArthur Foundation, 2013cited by Ogunmakinde, 2019). Stakeholders in the built environment demand the construction of sustainable projects due to their increasing benefits and relevance (Zainul, 2009; Robichaud and Anantatmula, 2011); it improves the performance of the projects (Zainun, Rahman and Rothman, 2016).

Although consensus is yet to be reached on what sustainability should mean in the built environment (Lombardi *et al.,* 2019). However, managing waste in all construction processes will enhance social life, economic growth and environmental health, especially if the circular economy is embraced and all actors are involved (Garas, Anis and Gammal, 2021). Lack of teamwork among the project stakeholders has been identified as a factor responsible for the lack of sustainable integration of construction projects (Abugu, Idris and Irene, 2022).

Several literature on construction sector abound and sustainability has become a major issue in construction and infrastructural development. Some of the studies include; Fagbemi *et al*., 2022, Oladinrin *et al*, 2012, Deinne, 2021, Madu, 2007, Hrabec et al, 2019, Picart and Rauf., 2021, Ogunmakinde, 2019, Ajayi et al, 2017, Wang, et al, 2014, Osmani et al, 2008 and among others. However, in the present study area there exist little or no empirical studies on the socio-economic and environmental implications of construction wastes in the study area and therefore this constitutes the focus of this study.

**2 Theoretical Formulation for the study**

This study is predicated on the theory of linear economy or Takes –Makes-uses-Dispose Theory which is illustrated in figure one.

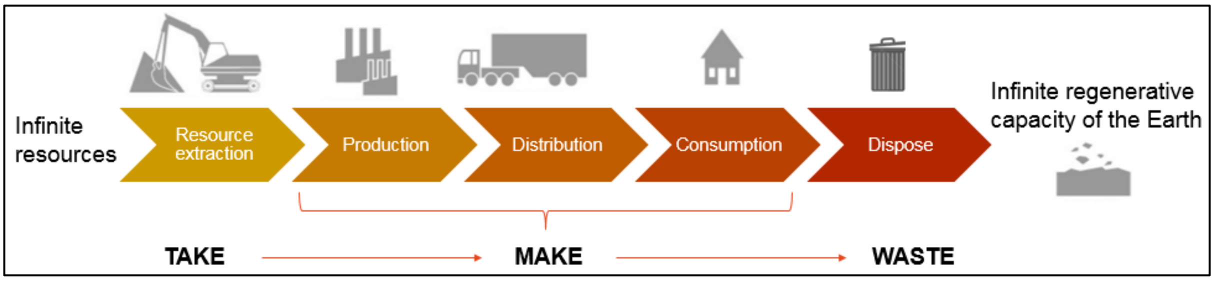


Figure 1: Diagramatic Illustration of Linear Economy Source: Wautelet, (2018).

Kightlinger (2023) posited that the construction industry has followed a straight line from extraction of resources to disposal of waste:

i. Take refers to extracting raw materials including energy from the environment and turning them into construction materials.
ii. Transforming these resources lets the industry make finished products, such as buildings but often in ways that lead to end-of-life obsolescence.
iii. With no value or possibility of reuse, the waste often ends up in landfills or incinerators and can harm the environment if not properly managed.

The life of the final product in a linear economy ends after the customer's usage, whereas the life of the final product in the circular economy is used as a basic resource throughout the production process (Mangialardo and Micelli, 2018). The construction industry traditionally presents a linear economic model, based on "take, make dispose of" (Ellen MacArthur Foundation 2015). This is due to its great capacity to produce and to dispose of fast-moving consumer goods. In particular, considering the built environment, the phases that characterize the linear economy start from the extraction of virgin materials; then they are processed to create new products often the finished product can't be disassembled the elements are assembled on site, generating wastes; once they become obsolete, they are discarded, often before the real end of their useful life (Mangialardo and Micelli, 2018). In this study, linear economy will be regarded as wasteful, unfriendly, unsustainable economy that is obsolete, no longer feasible in the current dispensation of paradigm shift to sustainable approaches.

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## 2. Materials and Methods

*2.1 Study Area*

Abuja FCT is located in North Central Nigeria. It approximately lies between longitudes 6° 46′ and 7° 37′ E and latitudes 8° 21′ and 9° 18′ N. It covers an area of approximately 8000 $km^2$ with a mean elevation of 476 m above sea level (NGDPR, 2020) (Fig. 2). Geologically, the study area belongs to the western province of the basement complex. The observed tectonic structures are N–S to NNE–SSW trending, resulting from the pan African Orogeny, which involved the collision between the West African craton and pan African mobile belts (Alagbe, 1979). Crystalline and sedimentary rocks extensively outcrop in the study area, representing 85% and 15%, respectively.

The study area lies in the tropical Sudan savannah region of Nigeria. The vegetation is forest and savannah, mostly comprised of woody plants (Agbelade et al., 2017). The temperature is usually between 18ºC and 37ºC. The Harmattan wind, a dust laden continental tropical air mass from the Sahara Desert, prevails throughout the period. The rainy season is between April and October, with most of the precipitation occurring in August or September (Jimoh andWojuola, 2009). The mean annual precipitation in the area is approximately 1200 mm (FCT Handbook, 1994). Despite the amount of annual precipitation, the tropical temperatures are reflected in high evapotranspiration rates, which account for the major water loss. The mean recharge rate estimated in Nigeria is lower than 15% of the total rainfall (Japan International Cooperation Agency, 2014) with small differences in each catchment (Ashaolu et al., 2020).

Abuja is Nigeria's administrative and political Centre; the people of FCC, in addition to the administrative role are also engaged in a diverse trade, manufacturing and few farming activities located around the rural areas in the Federal Capital City. Agricultural activities in the FCC have been greatly reduced by infrastructural development of the area and the fact that it is found within the guinea savanna belt (Balogun, 2001). However fertile soils in the FCC supports the cultivation of crops such as maize, Guinea corn, Millet, Rice, Yam, cassava and a variety of vegetables and fruits in the few undeveloped parts (Muhammad *et al*., 2018). As a centre of attraction for business, commercial activities have also been on the increase in Abuja.

Common businesses in the FCC, include sales of building and construction materials, provision of hotel and accommodation services, shopping complexes that provide household items, fashion shops, pharmacies, foodstuff markets, furniture markets as well as the sale of electronics and communication equipment. In recent times, there has been an increase in transport services, fast foods outlets and recreational centre (Ahmadu, 2021). This is due to the continuous influx of people into the FCC. The rapid increase in population and the multiplicity of commercial activities in the FCC are placing huge pressure on the FCT's infrastructure and social amenities including health care facilities, housing, electricity and water supply and housing need to be carefully developed to withstand the growing climate extremes in the area. Thus, construction waste management should be taking seriously to sustain the infrastructural development.

The Federal Capital City (FCC) was divided into phases for easy coordination of infrastructural development efforts. The development programme of the Federal Capital City FCC is broadly defined according to phases (I-V) as well as other developments within the city (Ahmadu, 2021). The FCC is rich in infrastructure such as expanding road network, houses, and drainage and sewage systems. There are numerous governmental institutions, foreign embassies in the FCC (Tini and Shah, 2018). The Abuja Master plan is the bane for the development of the Federal Capital City (FCC). The FCC was originally being developed in four phases (Aliyu, 2016). However a fifth was later added, land for which was obtained from AMAC (Villa Afrika Realty, 2023). Within each phase there are districts and within each district there are neighbourhoods (Aliyu, 2016). Each district has land allocated for residential, commercial, educational and recreational uses. Phase 1 is fully developed and has the most sought after, inner districts (Ezonbi and Jonah, 2022). Most of these neighbourhoods are established, with excellent infrastructure in place (Aliyu, 2016). The road network linking these areas to each other is extensive (Tini and Shah, 2018). The majority of official commercial and government related activities take place in these districts (Villa Afrika Realty, 2023).

The relocation of the seat of power from Lagos to Abuja in the late 70s has attracted construction companies who mainly foreign to develop infrastructure in Abuja. There are lots infrastructural developments since Abuja become the Federal Capital Territory (Tini and Shah, 2018). There are building constructions for residential, office and commercial structures. The development of civil engineering works like roads, bridges, airports, dams, canals and factories has also progressed in Abuja (Ezonbi and Jonah, 2022).

Notable building infrastructure in Abuja include: Nigerian National Mosque, Nigerian National Christian Centre, Millennium Tower, Nigeria Cultural Centre, Central Bank of Nigeria headquarters, the Nigerian Presidential Complex, the Ship House, National Mosque, Millennium Park, Eagle Square, Ministry of Defense (Ship House), The Presidential Palace (commonly referred to as the Aso Rock), Transcorp Hilton Abuja, ECOWAS secretariat, Nigerian Communications Commission Headquarters (NCC), National Universities Commission (NUC), Soil Conservation Complex, and Independent National Electoral Commission (INEC). The British High Commission, Maitama District Hospital, National hospital, Jubilation Avenue, Mount Pleasant Haven and Hilltop Estate, Gwarimpa Housing Estate, The ECOWAS Court, Jabi Lake Mall. There also building infrastructure for educational activities, examples are African University of Science and Technology, Baze University, National Open University of Nigeria, Nile University of Nigeria, University of Abuja, Veritas University, Philomath University. The Centagon International School, Maitama, American International School of Abuja, Whiteplains British School, Jabi, École Française Marcel Pagnol and Abraham Lincoln American Academy, Abuja.

Civil infrastructure includes many road constructed in Abuja, such as Oladipo Diya Road, Nnamdi Azikiwe Express Way, Ahmadu Bello Way, Aguiyi Ironsi Way, in Maitama, Abuja is also linked to Nasarawa, Niger, Kogi, Plateau, Benue and Northeast Nigeria by the Federal Highways. Others include Nnamdi Azikiwe International Airport, Abuja National Stadium, Millennium Park, Gurara and Usman dams, Despite the numerous infrastructure in the area, Abuja is need of many more, as rapid increase in population, the multiplicity of administrative and commercial activities in the FCC are placing huge pressure on the FCT's infrastructure. The continuous development of infrastructure comes with a lot of environmental and socioeconomic implication due to resource use and waste generation. Assessment of the socio-economic and environmental sustainability practices in construction waste management in infrastructural development in the FCT Abuja is essential study.

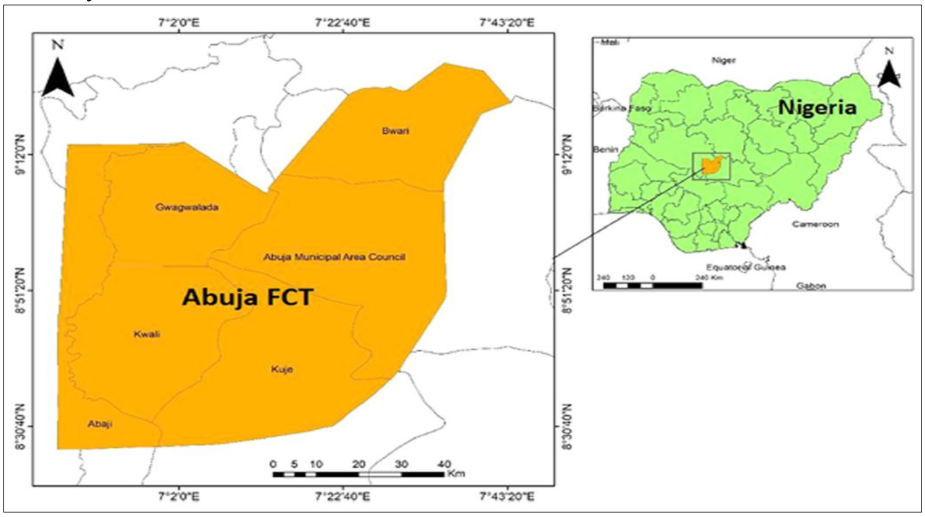


Figure 2: Map of the Study Area

*2.2 Method of Study*

Mixed method of study was employed to generate data. Data such as population of number of construction professionals/experts and volume of construction waste generation were collected from secondary sources while data were also collected from questionnaire administration, key informant interview and field observations which constituted the primary sources of data for the study.

In this study, the population included all construction professional/experts in major construction companies handling the construction of infrastructural projects within the FCC. Seven companies (Julius Berger Nigeria PLC, CGCC Group, Gilmo Nigeria LTD, Dantata and Sawoe Construction Company (Nigeria) Ltd, Ceezali Nigeria Limited, Arab Contractors, and Kaakata Nigeria Limited) out of thirty-one register construction companies in FCC, these companies were purposely selected based on their outstanding and numerous contracts in infrastructure project in FCC. The sample frame was all the professionals and experts in the seven companies purposively selected for the study. The report of (Coffey International, 2014 as cited in Afolabi, 2016) has indicated that "mega international firms usually employ 2000-20000 workers". The population of the seven selected companies was estimated to be eighty thousand, nine hundred and seventeen (80,917) people based on number of professional staff given by companies as shown in table 1.

Table 1: Population of Professional/Experts Across the Selected Companies

| S/N | Firm | Estimated Population |
|---|---|---|
| 1 | Julius Berger Nigeria PLC | 12,355 |
| 2 | Ceezali Nigeria Limited | 11,323 |
| 3 | CGCC | 11,845 |
| 4 | Gilmo Nigeria LTD | 11,321 |
| 5 | Dantata and Sawoe | 11,316 |
| 6 | Arab Contractors | 11433 |
| 7 | Kaakata Nigeria Limited | 11,324 |
| | Total | 80,917 |

*2.3 Sample Size Determination*

Sample size was determined using the Krejcie and Morgan (1970) table for determining sample size from a given population at 5% error margin.

Following the Krejcie and Morgan table the samples size for the study population is put at 382. Also, the sample size for each of the company was determined using a proportional representative as shown in table 2.

Table 2: Sample Size for Each Firm

| Firm | Estimated Population | Sample Size |
|---|---|---|
| Julius Berger Nigeria PLC | 12,355 | 58 |
| CGCC | 11,845 | 56 |
| Gilmo Nigeria LTD | 11,321 | 53 |
| Dantata and Sawoe | 11,316 | 53 |
| Ceezali Nigeria Limited | 11,323 | 54 |
| Arab Contractors | 11433 | 54 |
| Kaakata Nigeria Limited | 11,324 | 54 |
| Total | 80,917 | 382 |

Source: Field Survey (2022)

*2.4 Sampling Techniques*

First, purposive sampling technique was used to select seven construction companies (Julius Berger Nigeria PLC, CGCC, Gilmo Nigeria LTD, Dantata and Sawoe Construction Company (Nigeria) Ltd, Ceezali Nigeria Limited, Arab Contractors and Kaakata Nigeria Limited) in FCC. The companies were purposely selected for sampling based on their outstanding and numerous contracts in infrastructure project in FCC. Secondly, simple random sampling technique was used to select respondents from each company based on the companies' employees register.

*2.5 Techniques for Data Analysis*

Data were presented in tables and analysed using descriptive statistics such as mean, percentage, ranking, Z score, T test, ANOVA and Principle Component Analysis. All analysis were performed using the following statistical software's; R version 4.3.2, SPSS version 27 and the Microsoft Excel Package.

## 3. Results

3.1 Types of Construction Waste Generated in the Study Area

The result for the type of construction waste generated in the study area is presented in Table 3. Table 3 shows that construction wastes generated in the study area are mixed sand, concrete, asphalt, reinforcement bar, bricks/block, tiles, wood, carton, metals, ceramics, oil and grease, others. The mean and percentage scores for type of construction waste generated are as follows: mixed sand 52.64 ± 6.64 (15.45%), concrete 42.93 ±5.62 (12.60%), asphalt 21.79 ±3.22 (6.39%) reinforcement bar 17.16 ±5.00 (5.04%), bricks/block 42.84 ±4.29 (12.57%), tiles 25.24 ±1.14 (7.41%) wood 36.04 ±4.13 (10.58%), carton 15.46 ±5.03 (4.54%), metals 13.68 ±1.65 (4.01%) ceramics 13.68 ±1.65 (4.01%), oil and grease 31.93 ±6.47 (9.37%) and others 27.39 ±10.98 (8.04%). It shows that mixed sand is the most common construction waste generated in the study area followed by concrete, bricks/block, wood, oil and grease, tiles, asphalt, reinforcement bar, carton, metals, ceramics and others. The Z-score values shows that only mixed sand, concrete, bricks/block and wood scored approximately 1 and above. Thus, mixed sand, concrete, bricks/block and wood scored above average and thus, are the common types of construction waste in the study area.

Table 3: Types of Construction Waste Generated in the Study Area

| Companies | Julius Berger Nigeria PLC | CGCC | Gilmo Nigeria LTD | Dantata and Sawoe | Ceezali Nigeria Limited | Arab Contractors | Kaakata Nigeria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Size | 58 | 56 | 53 | 53 | 53 | 54 | 53 | Mean | %Score | SD | Z-score |
| Construction Waste | Frequency (%) | | | | | | | | | | |
| Mixed Sand | 52.20 | 53.20 | 50.35 | 51.94 | 46.64 | 47.52 | 66.64 | 52.64 | 15.45 | 6.64 | 1.93* |
| Concrete | 46.40 | 47.60 | 45.05 | 46.64 | 41.34 | 42.12 | 31.34 | 42.93 | 12.60 | 5.62 | 1.17* |
| Asphalt | 17.40 | 20.72 | 19.61 | 19.61 | 24.91 | 25.38 | 24.91 | 21.79 | 6.39 | 3.22 | -0.50 |
| Reinforcement Bar | 16.82 | 14.56 | 13.78 | 12.19 | 17.49 | 17.82 | 27.49 | 17.16 | 5.04 | 5.00 | -0.86 |
| Bricks/block | 27.84 | 25.20 | 23.85 | 22.26 | 16.96 | 17.28 | 26.46 | 42.84 | 12.57 | 4.29 | 0.90* |
| Tiles | 23.20 | 25.76 | 24.38 | 25.97 | 25.97 | 26.46 | 24.93 | 25.24 | 7.41 | 1.14 | -0.23 |
| Wood | 40.60 | 40.32 | 38.16 | 37.63 | 32.33 | 32.94 | 30.33 | 36.04 | 10.58 | 4.13 | 0.62* |
| Carton | 14.50 | 12.88 | 12.19 | 10.6 | 15.9 | 16.2 | 25.92 | 15.46 | 4.54 | 5.03 | -1.00 |
| Metals | 11.60 | 12.88 | 12.19 | 14.84 | 13.78 | 14.04 | 16.44 | 13.68 | 4.01 | 1.65 | -1.14 |
| Ceramics | 45.34 | 34.55 | 35.67 | 20.14 | 18.55 | 18.9 | 18.55 | 27.39 | 8.04 | 10.98 | -0.06 |
| Oil /Grease | 43.50 | 36.40 | 34.45 | 29.15 | 26.5 | 27 | 26.5 | 31.93 | 9.37 | 6.47 | 0.30 |
| Others | 8.70 | 10.64 | 10.07 | 11.13 | 12.72 | 12.96 | 12.72 | 13.68 | 4.01 | 1.65 | -1.14 |

*3.2 Volume of Construction Waste Generated in the Study Area (2000-2022)*

The first question on the volume of construction waste generated in the study area is meant to find out if the construction companies measure the volume of construction waste generated at site. To the utmost surprise, the responses were 100% negative. However, respondents were asked to estimate the volume of construction wastes generated by their company per day/annum (Tables 4 & 5). Table 4 presented the estimated volume of construction wastes generated by the companies per day.

Table 4: Perceived Estimated Construction Waste Generated in the Study Area Per Day(2000-2022)

| Companies | Julius Berger Nigeria PLC | CGCC | Gilmo Nigeria LTD | Dantata and Sawoe | Ceezali Nigeria Limited | Arab Contractors | Kaakata Nigeria Limited | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S. Size | 58 | 56 | 53 | 53 | 53 | 54 | 53 | Mean | SD | Rank |
| Volume of Waste | | | | Frequency (%) | | | | | | |
| < 100Kg | 31.03 | 21.43 | 43.40 | 30.19 | 20.75 | 44.44 | 20.75 | 30.29 | 9.51 | 2 |
| 100-200Kg | 65.52 | 62.50 | 45.67 | 33.96 | 43.40 | 53.70 | 43.40 | 49.74 | 11.35 | 1 |
| 201-300Kg | 3.45 | 8.93 | 5.66 | 16.98 | 15.09 | 1.85 | 16.98 | 9.85 | 6.01 | 3 |
| 301-400Kg | 0.00 | 3.57 | 1.49 | 9.43 | 9.43 | 0.00 | 11.32 | 5.04 | 4.89 | 4 |
| 401-500Kg | 0.00 | 1.79 | 1.89 | 5.66 | 7.55 | 0.00 | 5.66 | 3.22 | 2.81 | 5 |
| > 500KG | 0.00 | 1.79 | 1.89 | 3.77 | 3.77 | 0.00 | 1.89 | 1.87 | 1.54 | 6 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | |

Source: Field Survey (2023)

Result in Table 4 shows the perceived estimated volume of construction wastes generated by the companies per day. It shows that about one-third 30.29% ±9.51 ticked < 100Kg, 49.74% ±11.35 (100-200Kg), 9.85% ±6.01 (201-300Kg), 5.04% ±4.89 (301-400Kg), 3.22% ±2.81 (401-500Kg), and the remaining1.87% ±1.54 ticked (> 500KG). This suggests that the companies generate < 100 to 200kg of construction waste per a day. The ranking also shows that the frequency of 100-200Kg is highest followed by < 100Kg, 201-300Kg, 301-400Kg, 401-500Kg and least is > 500KG. Therefore, it can be deduced that the companies generate < 100-200Kg of waste per day.

Table 5 presents the estimated volume of construction wastes generated by the companies per Annum.

Table 5: Estimated Construction Waste Generated in the Study Area Per Annum (2000-2022)

| Companies | Julius Berger Nigeria PLC | CGCC | Gilmo Nigeria LTD | Dantata and Sawoe | Ceezali Nigeria Limited | Arab Contractors | Kaakata Nigeria Limited | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S. Size | 58 | 56 | 53 | 53 | 53 | 54 | 53 | | | |
| Vol.(tones) | | | | Frequency (%) | | | | Mean | SD | Z |
| < 1 | 21.03 | 11.43 | 33.40 | 20.19 | 12.25 | 24.44 | 16.75 | 19.93 | 7.01 | 0.00 |
| 1-2 | 75.52 | 72.50 | 55.67 | 43.96 | 53.42 | 63.71 | 47.40 | 58.88 | 12.11 | 1 |
| 3-4 | 3.45 | 8.92 | 5.66 | 16.99 | 15.09 | 11.85 | 16.98 | 11.28 | 5.05 | -0.39 |
| 5-6 | 0.00 | 3.57 | 1.49 | 9.43 | 8.23 | 0.00 | 11.32 | 4.86 | 4.73 | -0.67 |
| > 6 | 0 | 3.58 | 3.78 | 9.43 | 11.01 | 0 | 7.55 | 5.05 | 4.39 | -0.66 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | -0.69 |

Source: Field Survey (2023)

Result in Table 5 shows the frequency of estimated volume (tones) of construction wastes generated by the companies per annum as follows: <1(16.75% ±19.93), 1-2 (47.40% ±58.88),3-4 (16.98% ±11.28). 5-6 (11.32% ±4.86), and > (6 7.55% ±5.05). It means that majority

(47.40% ±58.88) posited that the companies generate 1-2 tons of construction waste per annum. The ranking values also show that 1-2tones scored the highest followed by < 1, 3-4, 5-6 and the least is > 6 tones. Therefore, the companies' annual waste generation is mainly 1-2tones. The results in Tables 4 and 5 were based on response to the questionnaire. The volume of construction waste generated in the study area 2000-2022 was also collected from AEPB (Table 6). Table 6 present the volume of construction waste generated in the study area 2000-2022.

Table 6: Volume of Construction Waste Generated in the Study Area 2000-2022

| Year | Quantity of Construction waste in Tones |
|---|---|
| 2000 | 9.56 |
| 2001 | 8.45 |
| 2002 | 8.24 |
| 2003 | 7.26 |
| 2004 | 5.67 |
| 2005 | 6.56 |
| 2006 | 7.35 |
| 2007 | 6.68 |
| 2008 | 6.48 |
| 2009 | 4.67 |
| 2010 | NA |
| 2011 | 5.48 |
| 2012 | 3.67 |
| 2013 | 4.39 |
| 2014 | 4.25 |
| 2015 | NA |
| 2016 | 2.12 |
| 2017 | 2.78 |
| 2018 | 5.34 |
| 2019 | 4.34 |
| 2020 | 3.29 |
| 2021 | 2.67 |
| 2022 | 3.58 |
| Mean | 3.45 |
| Standard Deviation | 1.01 |
| Coefficient of Variation | 29.28 |

Source: AEPB Solid Waste Management Unit

The result in Table 6 shows that mean annual volume of construction waste generated in the study area from 2000-2022 is 3.45±1.01with 29.28% coefficient of variation. It means that 29.28% lies below or above the mean. Thus, the volume of construction waste generated in the study area from 2000-2022 varies among the years (Figure 3). Figure 3 present the times series for the volume of construction waste generated in the study area from 2000-2022. Figure 3 show variation in the volume of construction waste generated in the study area from 2000-2022 as follows: the minimum amount (2.12tones) was recorded in 2015 whereas the maximum amount (9.54 tonnes) was recorded in 2000 the base year. It shows downward trend from 2000-2004 followed by an upward trend from 2005-2006. There was a slight uniform trend from 2006-2008 followed by a sharp decline in 2009. There were no records for 2010 and 2015. Sharp increase was observed from 2017 - 2018 followed by gradual decline from 2019 to 2021 before slight increase in 2022.

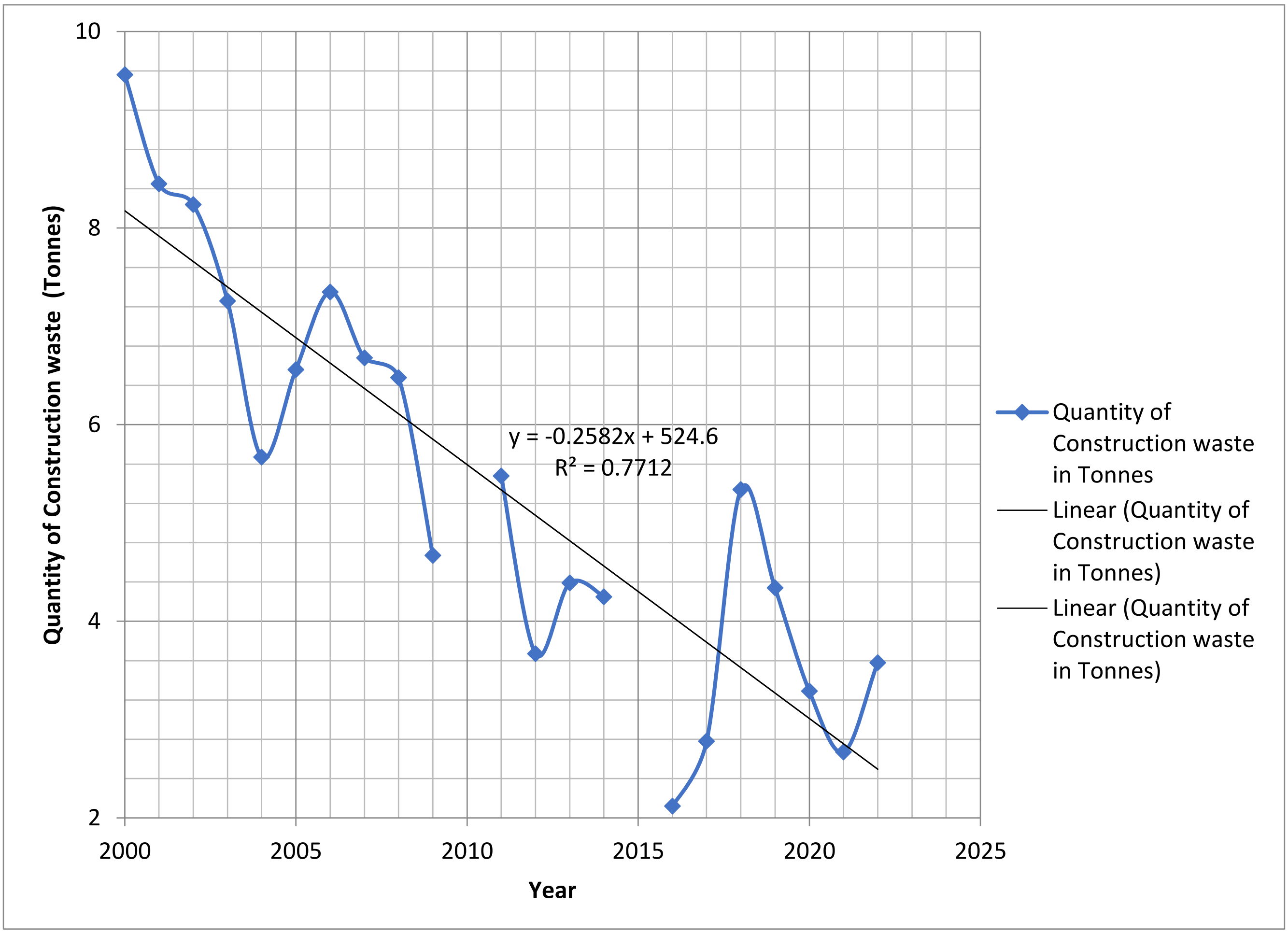


Figure 3: Variation in the Volume of Construction Waste Generated in the Study Area from 2000-2022

*3.3 Socioeconomic Sustainability via Material Efficiency and Waste Management in Construction Companies in the Study Area*

The frequency of material efficiency and waste management strategies applied by the construction companies to contribute to socioeconomic sustainability in the study area is presented in Table 7. Results in Table 7 shows the frequency of the following material efficiency and waste management strategies: material reuse on-site, designated location for recyclables on-site, waste management plan, waste recycling, waste re-furbishing, on-time delivery of materials, stocktaking of materials, and avoidance of over-ordering of materials.

Table 7: Material Efficiency and Waste Management Methods Used by the Company

| Companies | Julius Berger Nigeria PLC | CGCC | Gilmo Nigeria LTD | Dantata and Sawoe | Ceezali Nigeria Limited | Arab Contractors | Kaakata Nigeria Limited | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Size** | **58** | **56** | **53** | **53** | **53** | **54** | **53** | | | |
| **Methods** | **Frequency (%)** | | | | | | | **Mean** | **SD** | **Z-score** |
| Material reuse on-site | 43.50 | 36.40 | 34.45 | 29.15 | 26.5 | 27 | 26.5 | 31.93 | 6.47 | 1.15 |
| Designated location for recyclables on-site | 8.70 | 10.64 | 10.07 | 11.13 | 12.72 | 12.96 | 12.72 | 11.28 | 1.61 | -1.37 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Waste management plan | 16.82 | 14.56 | 13.78 | 12.19 | 17.49 | 17.82 | 27.49 | 17.16 | 5.00 | -0.65 |
| Waste recycling | 11.60 | 12.88 | 12.19 | 14.84 | 13.78 | 14.04 | 16.44 | 13.68 | 1.65 | -1.08 |
| Waste re-furbishing | 14.50 | 12.88 | 12.19 | 10.6 | 15.9 | 16.2 | 25.92 | 15.46 | 5.03 | -0.86 |
| On-time delivery of materials | 40.60 | 40.32 | 38.16 | 37.63 | 32.33 | 32.94 | 30.33 | 36.04 | 4.13 | 1.66 |
| Stocktaking of materials | 27.84 | 25.20 | 23.85 | 22.26 | 16.96 | 17.28 | 26.46 | 22.84 | 4.29 | 0.04 |
| Avoidance of over-ordering of materials | 45.34 | 34.55 | 35.67 | 20.14 | 18.55 | 18.9 | 18.55 | 27.39 | 10.98 | 0.60 |

Source: Field Survey (2023)

Result in Table 7 shows the frequency of material efficiency and waste management strategies applied by the construction companies to contribute to socioeconomic sustainability in the study area as follows: material reuse on-site (26.5% ±31.93),designated location for recyclables on-site (12.72% ±11.28),waste management plan (27.49% ±17.16), waste recycling (16.44% ±13.68), waste re-furbishing(25.92% ±15.46), on-time delivery of materials ( 30.33% ±36.04), stocktaking of materials (26.46% ±22.84), and avoidance of over-ordering of materials (18.55% ±27.39). The Z-scores for the material efficiency and waste management strategies applied by the construction companies to contribute to socioeconomic sustainability in the study area shows that some strategies are applied more than the others. The Z-score value for material reuse on-site is 1.15, on-time delivery of materials (1.66), and avoidance of over-ordering of materials (0.60) are approximately 1 and above. Thus, material reuse on-site, on-time delivery of materials, and avoidance of over-ordering of materials scored above average whereas other strategies to material efficiency and waste management such as designated location for recyclables on-site, waste management plan, waste recycling, waste re-furbishing and stocktaking of materials scored below average. This suggests variations on the applications of material efficiency and waste management strategies in the study area.

### *3.4 Constrains to Sustainable Construction Waste Management in the Study Area*

The constraints to sustainable construction waste management in the study area are presented in Table 8. Table 8 shows constrains to sustainable construction waste management in the study area such as ignorance by clients, inadequate knowledge, low interest in sustainable contractions, cost, poor access to waste treatment technologies, financing, poor attitudes, insufficient proper waste recycling markets, availability of cheap material and rush for project completion.

Table 8: Constraints to Sustainable Construction Waste Management

| Constraints | Frequency |
|---|---|
| Ignorance by clients | 245 |
| Inadequate knowledge | 236 |
| Low interest in sustainable contractions | 123 |
| Low priority for sustainable agenda | 135 |
| Cost | 341 |
| Poor access to waste treatment technologies | 354 |
| Financing | 278 |
| Poor attitudes | 231 |
| Insufficient proper waste recycling markets | 212 |
| Availability of cheap material | 127 |
| Rush for project completion | 324 |

Table 8 show the number of respondents that mentioned each constraints to sustainable construction waste management in the study area. Principal Component Analysis (PCA) was used to group and analyze the identified constraints into more manageable size. These constraints like ignorance by clients, inadequate knowledge, low interest in sustainable contractions, cost, poor access to waste treatment technologies, financing, poor attitudes, insufficient proper waste recycling markets, availability of cheap material and rush for project completion were first correlated. The correlation patterns of constraints to the sustainable construction waste management were both positive and negative. By implication, inverse and associative relationships exist from the interaction of the constraints to sustainable construction waste management in the study area. The relationship between some variables were weak, however, no particular pattern can be deduced from the relationship. There are instances of auto-correlation and multiple relationship among some variables, the problem of lack of a clear explanatory pattern and mixed relationship among variables in the correlations were resolved through the use of Principal Component Analysis. On the basis of Kaiser principle, three components were extracted using the variable maximization (varimax) method with Eigen-values of 5.45, 4.62 and 3.10 and percentage contributory variances of 32.93%, 30.58% and 21.58% respectively (Table 9).

Table 9: Principal Components of Constraints to Sustainable Construction Waste Management

| Variables | Component I (Environmental Negligence) | Component II (Knowledge) | Component III(Cost) |
|---|---|---|---|
| Ignorance by clients | -0.282 | 0.868* | -0.106 |
| Inadequate knowledge | -0.275 | 0.819* | 0.236 |
| Low interest in sustainable construction | 0.869* | 0.342 | -0.312 |
| Low priority for sustainable agenda | 0.738* | -0.233 | -0.480 |
| Cost | -0.136 | -0.636* | 0.895* |
| Poor access to waste treatment technologies | -0.440 | -0.786* | -0.096 |
| Financing | 0.288 | 0.321 | 0.610 |
| Poor attitudes | 0.850* | -0.103 | -0.104 |
| Insufficient proper waste recycling markets | 0.859* | -0.105 | -0.207 |
| Availability of cheap materials | 0.305* | -0.143 | 0.095* |
| Rush for project completion | 0.590* | -0.727* | -0.097 |

| | Component I | Component II | Component III |
|---|---|---|---|
| Eigenvalue | 5.45 | 4.62 | 3.10 |
| % Variance | 32.93 | 30.58 | 21.58 |
| % Cumulative Explained | 32.93 | 63.51 | 85.09 |

Source: Field Survey (2023)

Component I have an Eigen-value of 5.45 explains 32.53% of the total variance. It has significant positive loading on five (5) variables (low interest in sustainable contraction, low priority for sustainable agenda, poor attitudes, insufficient proper waste recycling markets, and rush for project completion) but negative or insignificant loading on six variables (ignorance by clients, inadequate knowledge, cost, poor access to waste treatment technologies, financing, and availability of cheap material). All the variables with significant positive loadings touched on 'environmental negligence' so it is named environmental negligence. Component II has an Eigen-value of 4.62 explains 30.58%, of the total variance. It has significant positive loading on three (3) variables (ignorance by clients, inadequate knowledge, and poor access to waste treatment technologies) but negative or insignificant loading on eight variables (low interest in sustainable contraction, low priority for sustainable agenda, poor attitudes, insufficient proper waste recycling markets, rush for project completion, cost, financing, and availability of cheap material). All variables with significant positive loadings touched on Knowledge. Thus, it is named Knowledge factor.

Component III has an Eigen-value of 4.10 accounts for 21.58% of the total variance. It significant also has positive loadings on three (3) variables (cost, financing, and availability of cheap material) but insignificant negative loading on eight (8) variables (low interest in sustainable contraction, low priority for sustainable agenda, poor attitudes, insufficient proper waste recycling markets, rush for project completion, ignorance by clients, inadequate knowledge, and poor access to waste treatment technologies). All the variables with significant positive loadings touched on cost and thus, it is named cost factor.

It can be deduced from the result of the Principal Component Analysis of constraints to sustainable construction waste management in the study area is broadly grouped into three factors namely environmental negligence (32.93%), knowledge (30.58%) and cost factors (21.58%). Thus, all the variables used could explain 85.09% of constraints to sustainable construction waste management in the study area. Therefore, variables are relevant and significant factors to be considered for sustainable construction waste management in the study area.

## 4. Discussion

The finding that mixed sand, concrete, bricks/block and wood scored above average and thus, are the common types of construction waste in the study area is not in isolation. It agreed with Nazech, Zaldi and Trigunarsyah (2008) that excess from soil excavation, timber and reinforcing bars are the most dominant waste produced in construction projects. It is also in line Adewuyi et al. (2014) who investigated the level of construction material waste generated on building sites in South-South, Nigeria and recorded that the level of material waste was 11.69%, 12.10%, 10.45%, 14.54%, and 12.07% for concrete blocks, steel reinforcement, timber, and tiles respectively. It also aligned with Lau et al. (2008) who studied waste composition from three residential buildings in Malaysia and found that wood (56.2%), concrete (23.6%), brick (14%), metal (2.5%) and others (3.8%), such as ceramic, PVC pipe, and plaster, were materials wasted. In the same vein, a similar study in Thailand identified sand, wood, concrete, and ferrous metals as construction waste materials (Kofoworola and Gheewala, 2009). The finding however, differs from an earlier report where it was posited that sand and gravel constitute only 4%, of construction waste (Spain, 2001). It also contradicts the report of Rani (2017) that screw steel reinforcement is the highest of the waste material found during the project construction. A respondent asserted that sand is relatively cheaper that other construction material and thus, is the most construction waste generated. Material waste composition on project sites varies depending on the construction activities, methods, and country in which they occur (US EPA, 1998; Begum, Siwar, Pereira and Jaafar, 2006).

In general, the mean annual volume of construction waste generated in the study area from 2000-2022 show a negative trend as the trend equation is $y = -0.2582x + 524.6$. The coefficient of determination ($R^2$) was 0.771. The $R^2$ being 0.771 means that the variation is significant. This finding implies that construction waste in the study declined within the period of the study. This can be attributed to increasing awareness of environmental impacts from construction wastes which said to have led to the development of waste management as an important function of construction project management. According to Laquatra and Mark, (2011), decreasing landfill space has led to increasing costs of landfill disposal to the contractor. This suggests that companies have to manage their waste to reduce the cost of disposal. Moreover, a relatively lower number of materials is being wasted because of high-cost material that has promoted waste control on sites (Laquatra and Mark, 2004). The finding also corroborates the position of Sholanke et al. (2019) that construction companies in Nigeria have used a number of techniques in order to minimize and manage the generation of waste on their sites, some of which include: use of prefabricated elements; sorting of generated waste; open dumping; open burning; and composting disposal method.

It was found from the interview that generated construction waste are mostly sold to people who either use or resale the material. However, more efforts need to be applied to promote waste prevention and the initiatives to reduce, reuse and or recycle waste produced. Another possible cause of the declined in the quantity of construction waste as found during the interview is that the volume construction itself is higher in the earlier years than recently. According a respondent, the earlier years witnessed tremendous construction and demolitions than recent years. The high volume of construction and demolition waste from 2000-2005 was attributed to the activities of the authorities in the FCT to ensure the actualization of the Abuja Master Plan.

The following material efficiency and waste management strategies are applied by the companies to contribute to socioeconomic sustainability: material reuse on-site, designated location for recyclables on-site, waste management plan, waste recycling, waste re-furbishing, on-time delivery of materials, stocktaking of materials, and avoidance of over-ordering of materials. However, there is a significant variation on the methods apply by construction companies to contribute to socioeconomic sustainability via material efficiency and waste management in the study area at 95% confidence level. So, material reuse on-site, on-time delivery of materials, and avoidance of over-ordering of materials were significantly higher than other material efficiency and waste management strategies such as designated location for recyclables on-site, waste management plan, waste recycling, waste re-furbishing and stocktaking of materials. Thus, it can be deduced that companies reuse material on-site, ensure on-time delivery of materials, and avoid over-ordering of materials but hardly do the follows:

i. Designate location for recyclables onsite
ii. Plan waste management
iii. Waste re-furbishing
iv. Stocktaking of materials

The implication of this result is that, the companies cannot contribute much to the socioeconomic sustainability of the study area via material efficiency and waste management.

All (100%) respondents disagreed that energy recovery from waste is practiced in on-site. This suggests that practice in the study area is not in line with current global moves to ensure energy recovery of wastes. Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion and landfill gas recovery (Palacio et al., 2018). It agreed with that assertion of Imam et al. (2008) that despite widely adoption of waste hierarchy as a guide for construction managers, in line with the principles of sustainable construction, most of the techniques are used sparingly applied in Nigeria. The design of a building and the materials that are procured strongly influences how waste on a construction project is generated (Gulghane and Khandve, 2015). It agreed with Dania et al. (2008) that the reuse of materials and sale as scrap such as timber for firewood was methods that are widely adopted. Other methods are recycling, reducing the number of materials used, controlled dumps and waste packaging.

A good number (30%) of respondents agreed that 'materials are locally sourced' but majority (70%) disagreed. Observation on-site also indicated that construction materials used were mainly foreign. Previous studies have also reported high dependent on foreign material use in construction as a challenge than can be overcome by looking into the local available materials. For instances, Gbonegun (2021) show that "Nigeria is blessed with abundant deposits of basic building materials, which if explored could be the solution to some imported components. The materials include clay, laterite, stone, lime, agro-industrial waste, wood/timber, glass and sand in their natural state". Alade et al. (2018) stressed that the potentials and benefits of local building materials (LBM) remain untapped and seem to progress at a slow rate in the Nigerian building industry. Ugochukwu and Chioma, (2015) also pointed that Nigeria in is endowed with abundant natural resources that can meet their building materials production, but still depend largely on imported building materials.

The finding that majority (69.50%) of construction material used in the study area are local materials corroborate and as well contradict previous reports. It supports the position of Gbonegun (2021) that Nigeria is blessed with abundant deposits of basic building materials, which if explored could be the solution to some imported components. The materials include clay, laterite, stone, lime, agro-industrial waste, wood/timber, glass and sand in their natural state. The result is tandem with Adafin et al. (2010) which stated that sourcing construction materials locally cut down on costs and the impact to the environment. The use of locally sourced materials by construction firms has numerous benefits, including reducing the carbon footprint, supporting the local economy, increasing quality control, promoting community growth, improving availability of materials, enhancing design, and supporting local culture (Adewuyi et al., 2014). According to (Ajayi et al., 2017), local materials and products can be less expensive, "greener," very unique aesthetically and help keep the local economy afloat. The use of locally sourced materials supports the local economy. Using locally sourced materials also improves the availability of materials. When materials are sourced from within the region, it eliminates the need for long lead times for materials to be delivered from a distant location. This can help to ensure that the construction project is completed on time, reducing the risk of delays and added costs.

However, it contradicts previous studies (Ugochukwu and Chioma, 2015; Alade et al., 2018; Irene, Magaji, Innocent & Abugu, 2023; Irene, 2024), which reported high dependent on foreign material use in construction. It disagreed with Ugochukwu and Chioma, (2015) who pointed that Nigeria is endowed with abundant natural resources that can meet their building materials production, but still depend largely on imported building materials. It contradicts the assertion of Alade et al. (2018) that the potentials and benefits of local building materials (LBM) remain untapped and seem to progress at a slow rate in the Nigerian building industry. Irene (2024) contrarily shows that good number (30%) of respondents agreed that 'materials are locally sourced' but majority (70%) disagreed.

Constrains to Sustainable Construction Waste Management in the Study Area are due to three main factors Environmental Negligence, Knowledge, and Cost. These factors are discussed as follows:

*Environmental Negligence as Constraints to Sustainable Construction Waste Management*

Environmental negligence variables such as low interest in sustainable contraction, low priority for sustainable agenda, poor attitudes, insufficient proper waste recycling markets, and rush for project completion account for 32.93% of constraints to sustainable construction waste management in the study area. This result is line previous studies. It aligns with the report of Hasan, Siddika, Islam & Ray (2022) which reported that "four most significant barriers that were identified hindering the effective CDW management are: 'Negligence and carefree attitude of workers', 'Poor supervision', 'Inadequate workers' skill', Space lacking for on-site storage''. It is tandem with the position of Jegede (2020) who posited that environmental laws are largely neglected in Nigeria. Environmental negligence is a persistent challenge in Nigeria. Environmental concern in Nigeria was brought to lime light in June 1988 following the discovery of toxic waste dumped in Koko town Delta state Nigeria (Ladapo, 2013). This created public outcry and prompted the government to react swiftly. Though, the Koko incident promoted environmental awareness of waste dump in Nigeria, environmental negligence has continued in all sectors. The environmental negligence has been reported in building sector (Jegede, 2020), farming (Agrawal, 2020), oil and gas (Eze, 2014). It also agreed with Hasan et al, (2022), that workers' careless attitude towards the environment is the main obstacle to implementing CDW management practice.

*Knowledge as Constraints to Sustainable Construction Waste Management*

Knowledge factors such as ignorance by clients, inadequate knowledge, and poor access to waste treatment technologies account for 30.58% of constraints to sustainable construction waste management in the study area. This result is not in isolation, previous studies that knowledge gab constrains sustainability. It agrees with Ayarkwa et al. (2022) revealed that inadequate training and education, and higher initial costs of green construction practices and materials are the key challenges that hinder implementation of sustainable building processes. It also aligned with the position of Dobrovolskien, et al. (2021) lack of knowledge and experience on how to use sustainability approaches hinders the advancement sustainability. It also corroborates the report of Udawatta et al. (2015) that inadequate experience and knowledge of workers hindered CDWM in Australia. Knowledge is big factor in construction waste management and thus, study by Liu et al. (2019) have suggested that "relevant knowledge relating to recycling, green materials, and emission reduction should be included in a community, high school or college education to increase knowledge about CDW management".

At the course of interview with stakeholders, a construction professional who preferred to be addressed as anonymous, pointed that sustainability is an environmental issue while construction is business and focus on gain. He misunderstood sustainability as constrain to construction rather than a conscious one. However, many respondents, who have good knowledge and interest on sustainability posited that proper localized framework and legislation are required to promote compliance to sustainable construction waste management. Thus, more training of construction professionals is required to promote sustainable construction waste management.

*Cost as Constraints to Sustainable Construction Waste Management*

Cost factors account for 21.58% of constraints to sustainable construction waste management in the study area. This result is agreed with previous knowledge. For instance, studies have indicated that it is difficult to achieve an adequate and sustainable construction in Nigeria due to problem of finance and others (Ibiam, 2009; Mimica, 2018; Yoade et al., 2018; Igbinoba, 2019; Gardner et al., 2020; Obianyo et al., 2021). According to Ibiam (2009) construction finance by its very nature is a capital-intensive venture. In order to deal with these problems, government has pursued a range of successive programmes and policies. Obianyo et al (2021) in a study "Overcoming the obstacles to sustainable housing and urban development in Nigeria: The role of research and innovation" identified poor funding mechanism as one of the major challenges. However, efficient deployment of cash resources for environmental proactive measures impacts positively on financial performance. Though, proactive environmental practices can generate an extra cost to the business at the onset, it enhances economic value at long run. It has been explained that sourcing fund from "international providers such as United Nations Office for Project Services (UNOPS), Shelter, Commonwealth Development Corporation (CDC) UK, International Finance Corporation (IFC)" would enable the construction companies to incorporate sustainability principles. Environmental, Social, and Corporate Governance (ESG) unit has been lunched in Nigeria to promote sustainable principles (Ayeyemi, 2022). It agreed with the position of Akomolafe, Oluwagbemi & Oyewo (2020) that issue of cost and payoff is still a major debate, as most environmentally friendly projects tend to be costly due to the application of new appliances and modern technologies.

## 5. Conclusion

Sustainable construction waste management in infrastructural development is the way- forward to enhance safety and resilience of infrastructure. The result shows that varieties of construction waste are generated in the study but the volume is on decline within the study period. Material reuse on-site, on-time delivery of materials, and avoidance of over-ordering of materials are the major strategies applied by the construction companies to contribute to socioeconomic sustainability via material efficiency and waste management in the study area whereas other modern strategies are less used. The majorities of construction materials area in the study area are sourced locally. The principal constraints to sustainable construction waste management in the study area are environmental negligence, knowledge, and cost factors. Thus, to promoted sustainability, environmental conscious education should be mandated for construction companies who are benefit driven.

## 6. Recommendations

The following were recommended based on the findings of this study:

Since construction waste is on the decline in the study area mainly due to reduction of construction work, the construction companies should increase efforts to maintain continuous decline in the volume of waste generated even when construction operation increases. This can be through judicious application of a well-developed plan that conforms to waste management hierarchy and circular economy.

The construction companies should improve on the applications of other waste management strategies that scored below average such as: ‘designated location for recyclables on-site”, ‘waste management plan’, ‘waste recycling’, ‘waste re-furbishing’, and ‘stocktaking of materials.

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