



Construction and Demolition Waste Management in a Developing Country: A Nigerian Scenario

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Abstract. Construction and demolition waste (CDW) is an important waste composition receiving attention from policymakers and researchers globally due to the negative impacts associated with its management. This paper explores construction and demolition waste management (CDWM) in Nigeria with a view to understanding CDWM's practices as perceived by policymakers, waste managers, and other stakeholders in the construction industry. A descriptive qualitative research design was adopted with data obtained from secondary sources. Findings revealed that CDWM is not a recent phenomenon in Nigeria but there is a renewed interest in it in the last decade. Findings also revealed that CDW does not receive the deserved attention from the constituted authority and stakeholders in the construction industry. While there is a low level of awareness regarding the negative impacts of CDW on public health and the environment, most construction firms and contractors have resorted to unsustainable disposal methods of open dumping, burning, and landfilling. Further findings revealed the potential for sustainable CDWM of reusing, recycling and composting. Finally, this paper recommends a tailored waste management strategy for CDW rather than the regular approach for municipal waste, legislation, stakeholder education, and engagement of the informal sector to drive sustainable CDWM in Nigeria.

Keyword:

Construction and demolition waste, Nigeria, Sustainable Development, Waste management

1. Introduction

Waste is regarded as the inevitable by-product of human activities [1]. Historically, waste generation was not a concern due to the ability of the environment to absorb the material being generated [2]. But over time, factors of rapid urbanisation, increased

population growth, economic development and change in consumption patterns triggered waste generation rates to an unprecedented level that its management became a challenge for municipalities.

Waste has been classified based on its origin, physical state, and physiochemical properties [3]. By origin, waste emerged from sources such as residential, industrial, commercial, institutional, construction and demolition, agricultural, and medical [4]. By physical state, it can be grouped into solid, liquid, and gas. And by physiochemical properties, waste is categorized based on composition, size, density (physical properties), moisture content, volatile solids, ash content, calorific value, etc. (chemical properties). Like other waste materials requiring management, construction and demolition waste (CDW) is increasingly gaining the attention of municipalities [5], because its improper management can impose negative economic, environmental, and social impacts [6]. While this constitutes a concern globally [7], different management approaches have been adopted by developing and developed countries [8]. Although developed countries have made considerable advancements in construction and demolition waste management (CDWM), developing countries are still lagging. Despite the efforts to recycle and reuse CDW, about 35% of this waste type still ended up in landfills without treatment worldwide annually [9]. For instance, it was reported that in Australia, about 27 million tonnes of construction and demolition trash were produced in 2018–2019, yet only 60% of this waste stream was recycled [6].

This paper explores the issue of CDWM in a developing country with a focus on Nigeria. It therefore aimed at understanding CDWM practices and their perception by policymakers, waste managers and other stakeholders in the construction industry. In addition, it seeks to identify gaps in the literature for future research directions.

2. Construction and Demolition Waste Management: An Overview

The history of construction waste management dated back to the second world war, when demolition waste was recycled in Germany to solve the problem of disposing of the large volume of demolition waste emanating from the war [10]. A primary source of CDW is infrastructures designated for demolition based on their limit states; a state of incipient failure, beyond which a structure ceases to perform as designed. Apart from this primary source, construction activities are other contributing sources of CDW due to excessive procurement of building materials, and the mishandling of the materials by the labourers [11]. Other human factors attributed to construction waste production include “recurrent design changes, errors in design and construction detail, and waste from cutting uneconomical shapes”, lack of knowledge and experience in construction waste, purchase of materials that are unsuitable to the specification, and inappropriate storage causing to failure and rework [12]. Natural disaster events such as earthquakes, floods, landslides, and tornadoes impact infrastructures often causing irreparable damages that generate a substantial amount of demolition waste.

There is no consensus regarding the operational definition of CDW. This has been attributed to diverse waste management philosophies and priorities [9]. In other words, CDW has been variously defined. A few of the definitions will be presented to provide focus in this paper. CDW constitutes “materials that are generated when new building and civil engineering structures are built, and also when current buildings and civil-engineering structures are renovated or demolished with deconstruction activities [13].”

Peru’s Ministry of Environment & Ministry of Housing and Construction and Sanitation 2016, defined CDW as “waste generated during construction, restoration, renovation, remodeling, and demolition of buildings and as a result of infrastructure activities and processes [14].” According to the decree-law 56/2015 of waste management, published in B.O. # 62 series I, of the Republic of Cape Verde, CDW is defined as: “The residue from construction, reconstruction, extension, alteration, maintenance and demolition of buildings and collapse [15].” However, in Nigeria, the National Environmental (Sanitation and Waste Control) Regulations (Section 106) interpreted "Construction and demolition debris" as materials that are normally used in the construction of buildings, structures, roadways, walk and other landscaping materials, and includes but is not limited to, soil, asphalt brick, mortar, drywall, plaster, cellulose, fiberglass fibers, gypsum board, lumber, wood, asphalt shingles, and metals [16]. From the definitions, it can be deduced that CDW emerged from various buildings and civil engineering activities ranging from construction, reconstruction, renovation, remodeling, and maintenance, to demolition. From the literature have also emerged various CDW classifications such as inert and non-inert waste [17]; tangible and intangible waste [18]; as well as direct and indirect waste [19]. These classifications of CDW influence the approach to its management.

a. Tangible and Intangible Construction Waste

Tangible construction waste comprises the combination of “used and unused materials that emerged from construction, demolition, and other construction-related activities.” They include concrete, bricks, tiles, reinforcement bars, wood, cardboard, paper, and topsoil. Intangible construction waste is referred to as “non-value-adding construction activities resulting in project costs and time overruns”. They are termed intangible because they consume resources without creating value. This waste type includes “overordering of materials, inappropriate storage of materials, construction process waiting time, and poor project and human management [18].”

b. Direct and Indirect Construction Waste

Direct waste is the type that occurs “at any stage of the construction process before the delivery of materials to the site and after incorporating the materials at the building. Conversely, indirect waste “occurs when materials are not physically lost but misused on site, causing monetary loss.” A good example of indirect waste is when making concrete slabs thicker or larger than specified by the structural design. See Table 1 for the summary of the direct and indirect construction waste [19].

Table 1: Categories of Direct and Indirect Construction Wastes

	Category	Reason	Examples
	Delivery waste	During the transportation of materials to the site, unloading and placing in addition to the initial storage	Bricks, glassing
Direct waste	Cutting and conventional waste	Cutting materials into various sizes and uneconomical shapes	Formwork, tiles
	Fixing waste	Dropped, spoiled, or discarded materials during the fixing	Bricks, roof tiles
	Application and residue waste	Hardening of the excess materials in containers and	Paint, mortar, plaster

	Category	Reason	Examples
Indirect waste	Waste caused by other trades	cans Damage occurs by succeeding trades	Painted surfaces
	Criminal waste	Theft and vandalism	Tiles, cement bags
	Management waste	Lack of supervision or incorrect decisions by the management	Throwing away excess material
	Substitution waste	Substitution of materials in work, which will incur losses to either contractor or client	Use of facing bricks for common bricks
	Production waste	The contractor does not receive any payments for the work he has carried out	
	Negligence waste	Site errors because of the condemned work or use of additional material	Over-excavation of the foundation resulting in the use of additional concrete
	Operational waste	Unavailability of proper quantities in the contract documents/the materials that are left on sites	Formwork

c. Inert and Non-inert Construction Waste

The inert materials consist of soft materials such as soil, earth, and slurry or hard materials of rock and broken concrete. On the other hand, non-inert materials are made up of timber, plastics, and packaging [17].

The management of CDW could also follow the waste management hierarchy concept, which involves a series of stages. In most developed countries, the 3Rs (reduction, reuse, and recycling) initiative is being implemented [12]. In addition to the 3R initiatives, composting and incineration have been identified as other invaluable options for CDWM [20]. The ensuing paragraphs will expatiate on these waste management strategies and their relevance to CDW.

As a waste management option, a reduction is considered a precautionary technique targeted at minimizing waste at the source [21]. It is advocated on the premise that if waste is avoided, fewer collection vehicles and refuse collectors are required, fewer and smaller waste handling facilities would be needed, and the extension of landfill lifespan would be achieved [22]. The emphasis here is the minimization of waste through avoidance instead of having to manage it after production [18].

Reuse involves reusing materials again through item recovery by cleaning and refurbishing [22]. Reuse of waste materials takes care of waste generated during transportation, offcuts, and low-quality materials. To achieve waste reuse, waste is sorted and stored either on-site or off-site. This waste management option eliminates additional transportation costs, brings about effectiveness in materials handling, and helps divert a significant proportion of waste from landfills. The variants of this method employed on construction sites are salvage, repair, remanufacture, refurbish, and repurpose [21].

Recycling is next to reuse in the waste hierarchy and is one of the methods employed in CDWM [23]. Recycling is about the transformation of waste into new products. Recycling construction waste offers benefits to the environment, economy, and society. From the environmental perspective, the benefits are the reduction in the waste volume taken to landfills thus prolonging the landfill sites lifespan; avoidance of the contamination of the groundwater through leakage from the construction waste noted for chemical additives; and reduction in the transportation requirements for waste destined for landfill sites thus minimizing the carbon IV oxide (CO₂) contribution to the environment. From the economic aspect, jobs are created for those involved in waste recycling as waste materials undergo some modification processes for the enhancement of the secondary product. Thus, new opportunities are not only created for the economy but the reduction of the negative environmental impacts of waste. And from the perspective of societal benefits, there will be an assured provision of more quality land for sub-division to meet housing demands because less land is required for landfills, human health, and other living organisms become free from toxic substances from construction materials disposed of in the landfills, and bad odors emanating from landfills affecting the nearby community [1]. Concrete recycling in particular has been shown to be theoretically possible under specific circumstances. Numerous laboratory trials, field testing, and extensive restoration efforts have proven this [23].

Composting involves breaking down the biodegradable component of waste into CO₂ and water in the presence of oxygen by microorganisms. The product of this process is compost used as fertilizer in agriculture or for land reclamation. Composting will help divert the biodegradable fraction of the CDW from landfills, which thus leads to the avoidance or reduction of greenhouse gas emissions and leachate [20].

Incineration is the combustion of waste to produce heat, CO₂, and oxygen. The emissions of various gases in the air by this option trigger massive opposition. When disposing of hazardous materials that are extremely flammable, volatile, poisonous, and contagious, incineration is the only method permitted. Good examples of hazardous materials found in CDW include asbestos, lead paint, lamp ballast (polychlorinated biphenyls [PCBs] and non-PCB), mercury-containing equipment (pressured gauges), flow meters, heating, and air conditioning thermostats tilt switches, and drain traps in old buildings [20].

The execution of the highlighted methods can be termed sustainable CDWM. However, a larger proportion of the CDW is still disposed of in landfills [24], even in developed countries. For instance, in developed countries such as the USA, Hong Kong SAR, Canada, and the UK, construction waste occupies 33-65% of the extant landfill space despite the implementation of the 3Rs (reduce, reuse, and recycling) initiatives [25]. This statistic suggests that CDW deserve attention among other waste type and stakeholders should urgently see to its effective and efficient management for sustainable development.

3. Demolition and Construction Waste Management: International Perspective

CDWM is a global issue, and as such, both developed and developing countries have a varying share of the problems associated with its management. This section presents

experiences from the two worlds. In developed countries, CDW is a problem because of high awareness of the environmental impacts associated with the CDW but their developing countries' counterparts are only concerned with building and completing infrastructure [12].

In developed countries, there is evidence of stricter regulations that guide the management of CDW. Additionally, each of these countries adopts measures that best suit them. For instance, in Spain, there is the implementation of on-site cleanliness and order, correct storage of raw materials, and prioritization of nearest authorized waste managers. Hong Kong on its part put in place the 3R initiative (reduce, reuse, and recycle) and polluter pays principle, which places obligations on contractors to create a waste management plan alongside waste reduction targets and programs [12]. The issue of CDWM in developed countries is not a recent phenomenon. While there has been an increased generation of CDW, the efforts to manage and divert the CDW from landfills are laudable as reported in Russia, Hong Kong, and the United Arab Emirates. For instance, Moscow deployed construction waste processing facilities in 2017 and achieved a secondary circulation of more than 80% of construction waste. Hong Kong recycles over 90% of the generated construction waste with the figure for 2016 put at 93% while the Al Dhafra Recycling Industries in Dubai City, established in 2008 and operated in 2010, extracted metals and other suitable materials from construction waste before the remaining material is processed to obtain 100% recycled aggregates and asphalt [26]. The successes recorded in developed countries can be attributed to the level of awareness and could be enhanced by stakeholders' support, regulations, and law enforcement [12]. The achievements of these countries indicate the successful implementation of sustainable construction [20].

On the other hand, the waste arising from developing countries has never been in doubt. Just like the developed countries, pieces of evidence abound of the bulk of CDW that ends up in landfills [12].

The Chinese experience with CDW revealed that the production rate is unprecedented. It was reported that about 1 billion tonnes of CDW were generated in 2013, an amount that was five times more than municipal solid waste at that time. About 5% of the CDW was reused or recycled. However, the measures to tackle the CDW in China have been described as incomplete when compared to municipal solid waste. Moreover, few cities in China with developed economic attributes have instituted actions towards CDWM but their regulations were considered not rigid and unenforceable to provide support for the minimization and environmentally sound management of CDW [20]. While waste recycling is seen to be a way out of the waste problem because of its potential to transform waste into wealth, the stakeholders' perceptions in China toward recycling CDW were found to be discouraging. Even the introduction of policies such as waste disposal charging fees to stimulate stakeholders' behavior towards recycling did not yield the desired results. Thus, an attempt to develop and introduce subsidy and environmental tax policies to encourage CDW recycling among the stakeholders is being made [28].

The Indian experience of CDWM is typical of developing countries. CDW constitutes 25% of the 48 million tonnes of solid waste generated per annum in India. Waste management by the construction industry in India entails the reuse of demolition materials that were rescued in excellent condition; the recycling of metals collected by scrap dealers; and the disposal of other materials in low-lying places. With regards to the

low application of recycling processes in India, the reasons advanced from various surveys revealed that “lack of awareness regarding recycling techniques as one of the major reasons for not adopting recycling of waste from the construction industry (70%), lack of awareness of recycling possibilities (30%), and non-availability of the recycled product to user industry (67%). And lastly, those industries with the knowledge and technical know-how lack specifications in Indian Standard Codes for the use of recycled material [10].

The Thailand scenario concerning CDWM indicated that there was a problem of selective management in which waste materials such as wood, plastic, paper, and metal are recycled whereas concrete, cement, and bricks constituting a larger proportion were sent to landfills. This neglect coupled with the approach adopted was hinged on the low cost and convenience offered by its management. This attitudinal problem among the construction operators was perceived as difficult so long as it is not rewarding economically [8]. In 2008, another study in Malaysia that focused on construction waste disposal practices in Ipoh City revealed that construction waste was dumped both at legal and illegal dumpsites in the city. Interestingly, variations were reported in the composition and quantity of construction waste disposed of at the legal and illegal dumpsites. While 9 tonnes of construction waste were estimated to be disposed of at the legal dumpsite, 12,351 tonnes were dumped at the illegal dumpsites. The illegal dumpsites identified include vacant land, dead-end roads, road reserves, former mining areas, and bushes. Illegal dumping was identified as the greatest challenge confronting the city. Other challenges faced by the city comprise insufficiently stringent legislation, lack of enforcement, inadequate facilities, inadequate collection network, low levels of awareness, and negative attitudes of communities [29].

A study conducted in Cape Verde indicated inadequate management of CDW imposes an impact on the city in the form of environmental degradation. The challenge was attributed to the non-existence of the CDWM plan. Despite the recognition of construction waste by the extant law governing waste management, there is a scenario of ambiguity regarding what constitutes construction waste, which gives room for multiple interpretations. Additionally, the national waste management plan that was intended to support the legislation was fraught with the problem of gravimetric interpretation of CDW composition where obvious items were missing [15].

4. Construction and Demolition Waste Management in Nigeria

Like in any part of the world, Nigeria is confronted with a waste management problem. While it is obvious that concerted efforts are being made to tackle the waste problem, little has been achieved regarding CDWM. A study established that government legislation on construction waste management was non-existent [19]. This has been complicated by poor understanding of waste management among the personnel of construction firms as well as a lack of policy by most companies [5]. In another study, it was observed that the problem with CDWM in Nigeria has nothing to do with awareness by the professionals in the construction industry rather it is about poor implementation of waste control techniques [30].

An increase in waste generation at the construction sites in the Lagos metropolis was reported, which calls for an urgent need to manage the waste to avert environmental hazards. The study revealed that demolition, renovation, and material handling as the primary causes of waste generation. It was also revealed that dumping in landfills was

mostly deployed as a construction waste disposal method. Finally, the recycling of construction waste was associated with problems such as collection and transport; sorting, transformation, and disposal; waste quantity; the size of the market; lack of information; organizational obstacles; time penalty clauses, and contamination [31].

A recent study assessed the current waste management strategies implemented in Nigerian construction projects by construction professionals in the Lagos metropolis and findings showed that waste management strategies employed were “not sustainable enough”. Findings indicated that major waste management strategies deployed are “re-use of materials as backfills; off-site preparation, preassembly, and prefabrication; provision of detailed information on drawings; and Building Information Modelling (BIM) implementation.” Additionally, the execution of identified strategies was below standards while most of the procurement procedures and their implementation were inadequate to bring about waste reduction. It was also established that CDWM implemented throughout the life cycle phases of the construction projects comprises the establishment of waste separation and collection techniques, and appropriate specifications on reusable, reclaimable, and recycled materials [13].

The assessment of the waste materials prone to waste and reuse methods on consumption sites was identified in the Ibadan metropolis. Of the 16 materials that are prone to waste selected for assessment, the prominent among them are reinforcement/steel, timber, concrete, and block/tiles. Building construction firms most often adopted repurpose, remanufacture, and salvage methods of materials, as waste reuse methods. These methods not only help achieve reduction but help to save procurement costs and time taken to purchase new construction materials [21].

The use of a waste management plan was studied at construction sites in Nigeria. The study showed the most important factors that trigger the effective implementation of the waste management plan are staff training, the setting of targets in developing a waste management plan and monitoring the waste plan for evaluation and readjustment [31]. The results of a review conducted regarding the effectiveness of construction waste minimization practices in Bauchi indicated that most construction and industrial sites are characterized by pollution. The pollution is attributed to the poor monitoring of construction works whether small or large projects [33]. The waste recycling option was examined in the face of engineering infrastructural development in Nigeria and the conclusion based on the laboratory experiments, field tests, and full-scale pavement rehabilitation projects was that concrete recycling to produce aggregate for construction is feasible. However, it was argued that Nigeria is yet to attain that level considering factors of technological development for concrete recycling and the market for various types of recycled aggregate concrete materials [23].

A study of construction waste management practices by construction firms in Nigeria particularly in some large cities comprising Kaduna, Lagos, and Abuja showed that construction professionals of the respective firms prioritized other project goals of timely project delivery, quality, and cost over the environmental impacts of the project. It was revealed that construction professionals had a poor understanding of construction waste management benefits, while most construction firms lack a waste management policy. Findings also revealed the poor adoption of different methods of construction waste management although reusing and scrap sales were the most adopted management methods owing to the greater utilization of timber and high scrap value for uses such as firewood. Among the factors influencing construction waste management practice,

project procurement cost reduction was the most important factor while lack of awareness was the primary factor hampering construction waste management practice. The commonest causes of waste production on construction sites are identified to be poor supervision, poor workmanship, and poor storage facilities [5].

In pursuit of sustainable construction in Nigeria, a study aimed at developing a circular-economy-based construction material waste minimization framework was conducted in Lagos. Findings revealed that concrete, timber products, and offcut tile dominated the waste types produced within the construction industry. The primary factors responsible for waste generation at different phases of the design phase (construction design changes), procurement phase (substandard material), and construction phase (supervision quality) were identified. While construction firms displayed a high level of awareness of the effects of materials, they showed positive attitudes to waste minimization. The design approach most frequently used to minimize waste is the design for material optimization while the least frequently used is the design for reuse and recycling. The reuse of formwork and scaffolding is the most significant of the 3Rs principle (reduce, reuse, and recycle). Furthermore, an organizational policy on waste minimization was non-existent for most of the construction firms sampled though a significant proportion (89.3%) were willing to adopt the new waste minimization method. Given the findings, a circular-economy-based construction waste minimization framework was developed based on the diffusion of innovation theory and this consists of five sections including identification of waste minimization needs, assessment of existing minimization measures, policy identification and formulation, identification of implementation methods, and evaluation of the proposed framework [18].

Regarding the factors that influence waste generation in building projects in southwestern Nigeria, determinants such as lack of early contractor involvement, undefined project brief, poor design quality, last-minute client requirements, frequent design changes and poor design, and engagement of inexperienced designers were found to be the most important factors [34]. In the south-south region of Nigeria, a study investigated the level of construction material waste generated on building sites to empirically establish the level of waste generated on building sites and compare such with the allowable value in estimates. The waste type selected for this study were concrete, blocks, steel reinforcement, timber, and tiles. Results obtained “established that there is no significant variation in the level of material waste generated on building sites among the states in the study area. Findings also revealed that “the actual waste generated on site is found to be higher than the allowable for all the five selected materials” [35].

In Abuja, an attempt was made to study waste minimization practices implemented at selected construction sites, and findings showed that there was no specific legislation governing the control of construction waste, rather construction professionals were concerned with completing projects within the time frame as far as the project is executed based on specification and within budget. Despite construction professionals agreeing to the need for the incorporation of site waste management practices, their respective firms lack implementation guidelines. The study recommends that government should introduce specific legislation that would govern the implementation of construction material waste management practices and ensure strict monitoring of compliance. It was also recommended that incentive schemes should be instituted by the government in form of tax rebates for companies that adopt modern construction

methods aimed at reducing the overconsumption of materials [19].

Similarly, an earlier study in Lagos assessed the forms, causes, and factors incidental to waste, and measures to effectively control construction waste. Findings showed that last-minute client requirement ranked as the highest factor that influences design variation; cost of construction materials was the most important factor that influences construction materials selection, while construction cost ranked highest among other factors that result in the selection of construction method. Results also indicated waste production was the least important factor as a cause of the selection of construction material while waste reduction was considered as not important as a factor affecting construction method selection. Less than one-fifth (14.29%) of the respondents stated that sorting of construction waste was carried out as it was hampered by the congested and limited space in most sites. The disposal methods adopted were open dumping (70.5%), open burning (16.0%), and composting (13.5%), while most construction firms do not calculate waste indices that could help determine the amount of waste that could be generated on-site [36].

Another study in Jos in Plateau State that investigated different approaches and processes of CDWM revealed that various CDW was generated ranging from sheet metal roofing, sand, gravel, concrete, masonry, metal, and wood among others. It was also found that construction companies take sole responsibility for CDWM while government agencies are concerned with the establishment of solid non-hazardous waste infrastructure systems, policies, and plans. About 60-70% of CDW materials are either reused, recycled, or resold, while the residual waste is indiscriminately disposed of by open dumping, landfilling, burning, and reuse by backfilling. Findings also established the non-existence of records on the quantity of CDW generated, lack of financial data, and lack of policies and plans for the CDW, which thus militate against the implementation of sustainable waste management strategy for Jos and Plateau State at large [37].

The reuse of CDW was investigated in Ilorin with the main objective to highlight the benefits of reusing CDW on a construction site. Both construction sites and a salvage market were visited for data collection. Findings revealed the specific CDW being reused, which include asphalt, land clearing residuals, wood, wooden door frames/window frames, louvers, asbestos, and metals. While most CDW are given away, others are sold at a low price thus helping to avoid storage and transportation costs that negatively affect the contractor's profit. Findings also revealed that poor management and lack of awareness of effective waste management are responsible for most of the construction waste [38].

5. Conclusion

The paper explored CDWM practices in Nigeria and the perception of policymakers, waste managers, and other stakeholders in the construction industry. The review revealed a renewed interest in CDW in Nigeria in the last decade which remains a challenge attributable to factors like rapid urbanization, population growth, and economic development. The review further revealed that CDW is still perceived and managed like municipal solid waste. The lack of policy, legislation, education, and regulation leaves stakeholders with no option but to use their initiatives in dealing with the CDW leading most construction firms and contractors to employ unsustainable approaches like open dumping, burning, and landfilling even though sustainable CDWM practices of reusing, recycling, and composting still exist. A thriving salvage market

suggests the involvement of the informal sector in the management of CDW. Finally, the research about CDWM in Nigeria indicated that they focused on the construction firms' professionals but there is a need for further research to capture other stakeholders, particularly the informal sector who have not received deserved recognition for their contributions to CDWM. It was also observed that research on CDWM has not been nationwide in outlook and as such a study should be extended to all the geopolitical zones in Nigeria to inform a comprehensive policy on sustainable CDWM. It would also be worthwhile if researchers explore the financial implications of CDWM in Nigeria as there is a dearth of such a study.

Given the findings highlighted, here are some recommendations. A tailored waste management strategy for CDW rather than the regular approach for municipal waste will be beneficial. For a more sustainable approach to CDWM, a structured framework of informed policy, implementation of legislation, stakeholder education, and enforcement of regulations involving all geopolitical zones in Nigeria is recommended. The informal sector should also be engaged in CDWM as they remain important stakeholders in this sector.

References

- [1] Purchase, C. K., Al Zulayq, D. M., *et al.* (2022). Circular economy of construction and demolition waste: A literature review on lessons, challenges, and benefits. *Materials*, 15, 76. Available at <https://doi.org/10.3390/ma15010076>
- [2] Gabriela, C. I. (2018). Waste recycling, the new-old challenge for sustainable urban development. *Journal of Urban and Landscape Planning* #3/2018, 99-113.
- [3] Madu, I. A. (2001). Urban solid waste problem in Nigeria. In E.O., Ezeani, & Elekwa, N. N. (Eds.), *Issues in urbanization and urban administration in Nigeria*. Jamoe Enterprises
- [4] Hoornweg, D., & Bhada-Tata, P. (2012). *What a waste: A global review of solid waste management No. 15* Urban Development Knowledge Series Papers. (World Bank, Washington. http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/What_a_Waste2012_Final.pdf
- [5] Dania, A. A., Kehinde J. O., & Bala, K. (2008). A study of construction material waste management practices by construction firms in Nigeria. <https://www.irbnet.de/daten/iconda/CIB10782.pdf>
- [6] Kabirifar, K., Mojtahedi, M., *et al.* (2020). A conceptual foundation for effective construction and demolition waste management. *Cleaner Engineering and Technology* 1, 100019, 1-12. <https://doi.org/10.1016/j.clet.2020.100019>
- [7] Elshaboury, N. & Al-Sakkaf, A. *et al.* (2022). Construction and demolition waste management research: A science mapping analysis. *International Journal of Environmental Research and Public Health* 19. <https://doi.org/10.3390/ijerph19084496>
- [8] Manowong, E. & Brockmann, C. (2012). Construction waste management in newly industrialized countries. https://www.irbnet.de/daten/iconda/CIB_DC24555.pdf
- [9] Menegaki, M., & Damigos, D. (2018). A review on current situation and challenges of construction and demolition waste management. *Current Opinion in Green and Sustainable Chemistry*. doi: 10.1016/j.cogsc.2018.02.010.
- [10] Markandeya R. Ponnada & Kameswari, P, (2015). Construction and demolition waste Management – A review. *International Journal of Advanced Science and Technology* 84,

- 19-46. Available at <http://dx.doi.org/10.14257/ijast.2015.84.03>
- [11] Olofinnade, O. M., Manda, I. *et al.* (2020). Management of construction & demolition waste: barriers and strategies to achieving good waste practice for developing countries. *IOP Conference Series: Materials Science and Engineering*, 1036, 012045. Available at doi:10.1088/1757-899X/1036/1/012045
- [12] Fitri, L., Hatmoko, J. U. D. *et al.* (2019). Managing construction waste in developed countries: lessons learned for Indonesia. *International Conference on Sustainable Infrastructure IOP Conference Series: Earth and Environmental Science* 366 012016. Available at doi:10.1088/1755-1315/366/1/012016
- [13] Aboginije, A., Aigbavboa, C., *et al.*, (2021). A holistic assessment of construction and demolition waste management in the Nigerian construction projects. *Sustainability*, 13, 6241. <https://doi.org/10.3390/su13116241>
- [14] Rondinel-Oviedo, D. R. (2021). Construction and demolition waste management in developing countries: a diagnosis from 265 construction sites in the Lima Metropolitan Area. *International Journal of Construction Management*. DOI:10.1080/15623599.2021.1874677
- [15] Vaz, L. E. S., Pontual, L. V., *et al.* (2016). Construction and demolition waste management scenario in Republic of Cape Verde—The case study of city of Praia. *Journal of Environmental Protection* 7, 2009-2017. <http://dx.doi.org/10.4236/jep.2016.713155>
- [16] Federal Republic of Nigeria – FRN (2009). *National environmental (sanitation and waste control) regulations 2009*. Abuja, Nigeria: Federal Government Printer
- [17] Poon, C. S. (2007). Reducing construction waste. *Waste Management* 27, 1715-6. Available at DOI: 10.1016/j.wasman.2007.08.013
- [18] Ogunmakinde, O. E. (2019). *Developing a circular-economy-based construction waste minimisation framework for Nigeria*, (Doctor of Philosophy in Building), The University of Newcastle, Australia.
- [19] Adeagbo, D. O., E. Achuen *et al.* (2016). Construction material waste management practices in selected construction sites in Abuja, Nigeria. *FUTA Journal of Management and Technology* 1(2), 96-104.
- [20] Yeheyis, M., Hewage, K., *et al.* (2013). An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability. *Clean Technologies Environmental Policy*, 15, 81–91. DOI 10.1007/s10098-012-0481-6
- [21] Akinradewo, O. F., Ogunmola, O. E. *et al.* (2020). Evaluation of materials waste reuse methods on construction sites in Ibadan metropolis, Nigeria. *INTREST – International Journal of Real Estate Studies*, 14(2), 39-47.
- [22] Medina, M. (2002). Globalization, development and municipal solid waste management in third world cities, 1-38. <http://www.gdnet.org/pdf/2002AwardsMedalsWinners/outstandingResearchDevelopment/martinmedinaMaetinezpaper.pdf>
- [23] Akinkurolere, O.O., Aribisala, J.O. *et al.* (2013). Construction waste recycling in sustainable engineering infrastructural development. *International Journal of Development and Sustainability*, 2(2), 1066-1074.
- [24] Akaakase, H. E., Kwaji, M. *et al.* (2017). Waste management on construction site. *International Journal of Environmental Studies and Safety Research (IJESSR)* 2(4), 29-48.
- [25] Agamuthu, P. (2008). Challenges in sustainable management of construction and

- demolition waste. *Waste Management & Research*, 26, 491–492. DOI: 10.1177/0734242X08100096
- [26] Aleksanin, A. (2019). Development of construction waste management. *E3S Web of Conferences* 97, 06040. <https://doi.org/10.1051/e3sconf/20199706040>
- [27] Duan, H. & Li, J. (2016). Construction and demolition waste management: China's lessons. *Waste Management & Research*, 34(5), 397–398.
- [28] Hua, C., Liu, C. *et al.* (2022). Promoting construction and demolition waste recycling by using incentive policies in China. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-022-19536-w>
- [29] Mahayuddin, S. A., Pereira, J. J. *et al.* (2008). Construction waste management in a developing country: Case study of Ipoh, Malaysia. *WIT Transactions on Ecology and the Environment*, 109, 481-489. doi:10.2495/WM080491
- [30] Sholanke, A., Aina-Badejo, T. *et al.* (2019). Noise pollution and waste control techniques in building construction in Nigeria: A literature review. *IOP Conference Series: Earth and Environmental Science* 331. doi:10.1088/1755-1315/331/1/012016
- [31] Ajayi, O. M., Koleoso, H. A., *et al.*, (2008). The practice of waste management in construction sites in Lagos State, Nigeria. *COBRA 2008 - The Construction and Building Research Conference of The Royal Institution of Chartered Surveyors Held at Dublin Institute of Technology, 4-5 September 2008*.
- [32] Oladiran, J. O. (2018). Optimization of Waste Management Plan for Waste Reduction on Construction Projects in Nigeria. *Proceedings: International conference on innovation in Architecture, Engineering and construction*, June 23-25, Antalya, Turkey.
- [33] Baba, B. & Suratkon, A. B. (2017). A review of effectiveness of construction waste minimization practices in Bauchi State, Nigeria. *3 Trajectoriâ Nauki = Path of Science* 2012-2015.
- [34] Tongo, S. O., Oluwatayo, A. A., *et al.* (2020). Factors influencing waste generation in buildings project in South-West, Nigeria. *Academia Journal of Environmental Science*, 8(4), 059-063. DOI: 10.15413/ajes.2020.0103
- [35] Adewuyi, T.O., Idoro, G.I., *et al.* (2014). Empirical evaluation of construction material waste generated on sites in Nigeria. *Civil Engineering Dimension (CED)*, 16(2), 96-103. DOI: 10.9744/CED.16.2.96-103
- [36] Wahab, A. B. & Lawal, A. F. (2011). An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology* 5(3), 246-254.
- [37] Benschak, A. B., Dabuhat, W. M. *et al.* (2021). An Assessment of the approaches of construction and demolition waste in Jos, Plateau State of Nigeria. *56th ISOCARP World Planning Congress in Doha, Qatar International Society of City and Regional Planners*.
- [38] Mudashiru, R. B. & Oyelakin, M. A. *et al.* (2016). Reuse of construction and demolition waste in Edun, Ilorin, North Central Nigeria. *International Conference of Science, Engineering & Environmental Technology (ICONSEET)*, 1(12), 85-89.