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ASSESSMENT OF THE BARRIERS TO THE IMPLEMENTATION OF DESIGNING OUT WASTE (DOW) IN THE NIGERIAN CONSTRUCTION INDUSTRY

***MOHAMMED, Saidu Minin and NUHU, Kamal Idi**

[1]Department of Quantity Surveying, Ahmadu Bello University, Zaria, Nigeria
***Correspondence**: smminin@yahoo.com

ABSTRACT
Construction and demolition activities in Nigeria generate substantial amount of wastes, posing significant environmental and economic challenges. Designing Out Waste (DOW) is a proactive design-phase strategy that aims to reduce construction waste through optimal design and material specification. However, the implementation of DOW has been limited due to several contextual barriers. This study examines the primary barriers hindering the adoption of DOW in the Nigerian construction industry. Data were collected through structured questionnaires administered to 218 construction professionals, yielding 127 valid responses (response rate: 58.6%). Using descriptive statistics and factor analysis, specifically mean score ranking, to determine the significance of each barrier. The study identified sixteen barriers, which were evaluated. The top-ranked barriers included a lack of awareness, insufficient skills, and the absence of relevant digital tools. The study identifies five overarching categories of barriers: knowledge-based, experience-related, design-technical, project-focused, and client-related. The findings underscore the need for systemic reforms, including awareness campaigns, policy support, technical training on DOW, and adoption of BIM and ICT tools. Conversely, contractual and client-related factors were perceived as less critical. This research contributes to the growing body of sustainable construction strategies in developing countries. It concludes that targeted interventions, focusing on awareness campaigns, professional training, and technology integration, are essential to overcome these barriers. It recommends pathways for enhancing DOW implementation for improved environmental and construction performance in Nigeria.

KEYWORDS: *Barriers, Construction waste, Design phase, Designing Out Waste (DOW), Waste minimisation*

INTRODUCTION
The global construction industry is a primary consumer of natural resources and a major generator of waste. Construction and Demolition (C&D) waste constitutes a significant portion of total solid waste worldwide, placing immense pressure on depleting landfill capacities and causing adverse environmental impacts (Huang *et al*., 2018; Kabirifar *et al*., 2020). In developing nations like Nigeria, rapid urbanisation and infrastructure development exacerbate this issue, making effective waste management a critical component of sustainable development (Wahab & Lawal, 2014).

Traditionally, C&D waste management has focused on downstream solutions such as recycling and disposal. However, a growing body of research emphasises the superior efficacy of upstream interventions that prevent waste at its source (Ajayi & Oyedele, 2017). The waste management hierarchy: Reduce, Reuse, Recycle (3Rs), prioritises reduction as the most effective strategy (Ghisellini *et al*., 2016). It is estimated that decisions made during the design phase influence up to 80% of a project's environmental impact, including waste generation (Osmani, 2013). This places designers in a pivotal role for waste minimisation.

Designing Out Waste (DOW) has emerged as a key proactive strategy that integrates waste minimisation principles directly into the design phase of a construction project (Osmani *et al*., 2008a). DOW involves practices such as designing for material optimisation, off-site construction, deconstruction, and flexibility, thereby reducing waste generation throughout the building lifecycle (Langdon, 2009). The adoption of digital tools such as Building Information Modelling (BIM) has further enhanced the potential of DOW by enabling precise material quantification, clash detection, and visualisation, which significantly reduces rework and material offcuts (Akinade *et al*., 2018; Liu *et al*., 2015).

Despite its recognised benefits, the implementation of DOW remains limited, particularly in developing countries. While studies have explored DOW barriers in various contexts (e.g., Osmani *et al*., 2008a in the UK; Hassan & Alashwal, 2024 in a broader context), there is a significant research gap concerning the specific challenges within the Nigerian construction industry. Previous research in Nigeria has often focused on general C&D waste management rather than the specific, upstream challenges of implementing DOW (Ajayi *et al*., 2017). The lack of a clear understanding of these context-specific barriers hinders the development of effective strategies to promote the implementation of DOW.

This study, therefore, aims to bridge this gap by systematically identifying and assessing the barriers to implementing DOW in the Nigerian construction industry. The specific objectives are to: identify the potential barriers to DOW implementation from existing literature; and assess the relative significance of these barriers from the perspective of Nigerian construction professionals. The findings will provide policymakers, professional bodies, and construction firms with valuable insights, enabling them to formulate targeted strategies that foster sustainable construction practices in Nigeria.

LITERATURE REVIEW

Designing Out Waste (DOW): Concept and Global Practices

DOW is defined as “an approach that controls resources effectively during the design phase of a project to reduce waste generated during the construction and demolition phases (Othman & Elsawaf, 2021). It operates across three tiers:

a) Strategic: Policy alignment, ISO 14001 certification, top-management commitment (Camilleri, 2022).
b) Guidelines: BS 8895 (UK), WRAP’s 5 Principles (Langdon, 2009).
c) Tools: BIM, design reviews, clash detection, modular coordination (Ajayi *et al*., 2017; Liu *et al*., 2015).

Global case studies confirm DOW reduces waste by 20-40% (Innes, 2004).

Barriers to DOW: Synthesis from Literature

Barriers are classified into five domains:

Table 1: Thematic Classification of DOW Barriers (Literature-Based)

Category	Key Barriers	Representative Studies
Knowledge and Awareness	Lack of awareness; Limited training; No formal DOW curriculum	Ajayi *et al*. (2016); Olanrewaju & Ogunmakinde (2020)
Skills and Tools	Lack of ICT/BIM skills; Absence of DOW software/tools	Akinade *et al*. (2018); Wong *et al*. (2021)
Design Process	Design complexity, Poor coordination, Frequent changes	Osmani *et al*. (2008a); Xu & Lu (2019)
Project Constraints	Time pressure; Budget limitations; No contractual clauses	Llatas & Osmani (2016); Salgin *et al*. (2020)
Stakeholder Dynamics	Client disinterest; Poor inter-professional collaboration	Wang *et al*. (2019); Ipsen *et al*. (2021)

Barriers to Designing Out Waste (DOW): Expanded Summary from Literature

DOW is an essential tenet of the circular economy in the built environment, shifting the focus from managing waste to preventing its creation. Successful DOW implementation requires a concerted effort from all project stakeholders, particularly the design team. However, numerous factors can impede its application. A review of existing literature reveals that these barriers can be broadly categorised into knowledge and skills, process and technology, and stakeholder-related challenges.

A seminal study by Osmani *et al*. (2008a) in the UK found that architects' lack of awareness and knowledge of waste issues, coupled with project constraints like time and cost pressures, were significant barriers. More recent studies have corroborated these findings and expanded the list of challenges. Hassan and Alashwal (2024) developed a comprehensive model that identified barriers, including a lack of client interest, design complexity, and poor collaboration among professionals. Similarly, Ajayi *et al*. (2016) highlighted the negative perceptions and attitudes of designers towards DOW as a significant hindrance. Based on an extensive literature review, sixteen key barriers were identified for investigation in this study. These are summarised in Table 2.

Table 2: Potential Barriers to DOW Implementation

Barrier ID	Barrier Description	References
B1	Lack of awareness of DOW	Ajayi *et al*. (2016); Liu *et al*. (2015); Osmani (2013)
B2	Lack of experience and skills in implementing DOW	Ajayi *et al*. (2016); Osmani *et al*. (2008b); Salgin *et al*. (2020)
B3	Designers' limited knowledge of construction processes	Ipsen *et al*. (2021); Olanrewaju & Ogunmakinde (2020)
B4	Lack of knowledge about standardisation (e.g., material sizes)	Ajayi & Oyedele (2018); Ekanayake & Ofori (2004)
B5	Lack of DOW tools, such as ICT tools (e.g., BIM)	Akinade *et al*. (2018); Llatas & Osmani (2016); Wong *et al*. (2021)

B6	Unclear Specifications	Implied from "Poor design" and "Lack of information" in multiple sources
B7	Design changes	Ajayi *et al*. (2016); Doust *et al*. (2021); Wang *et al*. (2014)
B8	Poor design	Liu *et al*. (2015); Osmani *et al*. (2008b)
B9	Design Complexity	Ajayi *et al*. (2017); Laovisutthichai *et al*. (2020); Osmani *et al*. (2008a)
B10	Changes in processes and practices of design	Ajayi & Oyedele (2018); Xu & Lu (2019)
B11	Lack of information, documentation, and drawings	Akinade *et al*. (2018); Olanrewaju & Ogunmakinde (2020)
B12	Project constraints (e.g., insufficient time or resources to review design)	Olanrewaju & Ogunmakinde (2020); Osmani *et al*. (2008a); Salgin *et al*. (2020)
B13	Lack of collaboration among professionals from different disciplines	Ajayi & Oyedele (2018); Mohammed *et al*. (2022); Ipsen *et al*. (2021)
B14	Designers' negative perception (behaviour and attitude) towards DOW	Ajayi *et al*. (2016); Wang *et al*. (2019)
B15	Lack of client interest in reducing waste	Osmani *et al*. (2008b); Olanrewaju & Ogunmakinde (2020); Wang *et al*. (2019)
B16	The contract does not specify reducing waste during the design phase	Akinade *et al*. (2018); Doust *et al*. (2021); Osmani (2013)

METHODOLOGY

This study adopted a quantitative research methodology to assess the barriers confronting DOW implementation in Nigeria. A descriptive survey design was employed to gather and analyse data from construction industry professionals systematically. The primary data collection instrument was a structured questionnaire. The questionnaire was divided into two sections. Section A captured the demographic information of the respondents, including their profession, years of experience, academic qualifications, and primary type of project involvement. Section B listed the sixteen potential DOW barriers identified from the literature (see Table 1). Respondents were asked to rate the significance of each barrier in hindering DOW implementation on a five-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

The target population for this study comprised registered construction professionals in Nigeria, including Architects, Builders, Engineers, and Quantity Surveyors. Based on 2024 registration data from professional bodies (ARCON - 5550, CORBON - 5350, COREN - 85179, QSRBN - 5159), the total population was estimated at 101,238. Using Taro Yamane's formula with a 92% confidence level (8% margin of error), a sample size of 156 was calculated. To account for non-responses, the number of distributed questionnaires was increased to 218 (Salkind, 1997). A simple random sampling technique was intended, with

questionnaires distributed electronically to professionals across various firms and projects in Nigeria.
The collected data were analysed using descriptive statistics with the aid of the Statistical Package for the Social Sciences (SPSS). Respondent demographics were analysed using frequencies and percentages. The primary analysis involved calculating the mean score and standard deviation for each of the sixteen barriers. The barriers were then ranked based on their mean scores to determine their relative importance as perceived by the respondents. Before conducting the main analysis, the suitability of the data for factor analysis was assessed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Wiesen, 2019) was 0.847 (Table 4). Bartlett's Test of Sphericity (Denis, 2018) was significant (Table 4) $\{\chi^2(120) = 599.721,\ p < 0.001\}$, indicating that the data were suitable for identifying underlying components. However, mean ranking was chosen as the primary analytical tool for this paper due to its directness and clarity.

RESULTS AND DISCUSSIONS

Response Rate and Respondent Demographics

A total of 218 questionnaires were distributed, and 127 were completed and returned, representing a response rate of 58.3%. This rate is considered adequate for analysis (Moser & Kalton, 1971). The demographic profile of the respondents is summarised in Table 3.

Table 3: Demographic Profile of Respondents (N=127)

Demographic Variable	Category	Frequency	Percentage (%)
Profession	Architect	13	10.2
	Builder	29	22.8
	Engineer	37	29.1
	Quantity Surveyor	48	37.8
Years of Experience	< 5 years	65	51.2
	5 - 10 years	35	27.6
	10 - 15 years	14	11.0
	> 15 years	13	10.2
Academic Qualification	HND / ND	20	15.7
	BSc / BTech	89	70.1
	MSc / MTech / PhD	18	14.2
Primary Project Type	Residential	48	37.8
	Mixed Development	24	18.9
	Infrastructure	14	11.0
	Engineering	30	23.6
	Industrial	11	8.7

The respondents represented a diverse mix of professions, with Quantity Surveyors (37.8%) and Engineers (29.1%) being the most represented groups. A majority of respondents (51.2%) had less than five years of experience, suggesting early-career professionals heavily influence the perspectives. Most respondents held a bachelor's degree (70.1%) and were primarily involved in residential projects (37.8%).

Factor Analysis: Barrier Dimensions

Table 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.847
Bartlett's Test of Sphericity	Approx. Chi-Square	599.721
	Df	120
	Sig.	0.001

Table 5: Factor Analysis

Component	**Eigenvalue**	**% Variance**	**Key Items**
Lack of Experience/Skills	4.12	25.8%	B2, B3, B7, B12
Knowledge-related	2.87	17.9%	B1, B11, B15
Design-related	2.15	13.4%	B4, B5, B6, B13
Project-related	1.32	8.3%	B10, B14, B16
Client-related	0.81	3.8%	B8, B9

Table 5 presents the results of an Exploratory Factor Analysis (EFA) conducted to uncover the underlying latent dimensions (factors) that structure the 16 identified barriers to Designing Out Waste (DOW) implementation in the Nigerian construction industry. Rather than treating each barrier in isolation, factor analysis groups conceptually related barriers into broader thematic domains, enabling more strategic and targeted interventions. Five components (factors) were extracted, collectively explaining 69.2% of the total variance, a robust result exceeding the recommended 60% threshold for social science research . (Hair *et al*., 2019). Each factor represents a coherent cluster of barriers sharing conceptual similarity. The naming of each factor was determined by examining the highest-loading items within that component and aligning them with established literature on DOW barriers.

Assessment of Barriers to DOW Implementation

The mean scores for the sixteen identified barriers were calculated to determine their perceived importance. The results, ranked from highest to lowest mean score, are presented in Table 6

Table 6: Ranking of Barriers to DOW Implementation in Nigeria

Barrier Description	Mean	Std. Dev.	Rank
Lack of awareness of DOW	3.64	1.166	1
Lack of experience and skills in implementing DOW	3.57	1.206	2
Lack of DOW tools, such as ICT tools	3.55	1.132	3
Unclear Specifications	3.53	1.147	4
Changes in processes and practices of design	3.52	1.104	5
Design Complexity	3.46	1.132	6
Designers' limited knowledge of construction processes	3.45	1.146	7
Lack of collaboration among professionals from different disciplines	3.43	1.238	8
Designers' negative perception (behaviour and attitude) towards DOW	3.42	1.042	9
Lack of knowledge about standardisation (e.g., material size in the market)	3.39	1.189	10
Lack of information, documentation, and drawings	3.39	1.261	11
Design changes	3.35	1.244	12
Poor design	3.28	1.303	13
Lack of client interest in reducing waste	3.26	1.128	14
Project constraints (e.g., insufficient time or resources to review design)	3.23	1.223	15
The contract does not specify reducing waste during the design phase	3.17	1.125	16

Table 6 presents the perceived severity of 16 identified barriers to Designing Out Waste (DOW) implementation in the Nigerian construction industry, as rated by 127 construction professionals using a 5-point Likert scale (1 = Strongly Disagree → 5 = Strongly Agree). The table ranks barriers based on their mean score, providing a clear hierarchy of which obstacles are perceived as most critical by practitioners on the ground.

Having used a 5-point Likert scale, the following interpretation guidelines were adopted. A Mean of 3.50 and above indicates strong agreement, that is, the barrier is perceived as highly significant. A Mean between 3.00 and 3.49 indicates moderate agreement, that is, the barrier is perceived as relevant but less critical. While a Mean less than 3.00 indicates low agreement, that is, the barrier is less influential or contested. In this instance, all 16 barriers scored above 3.0, confirming that every identified barrier holds practical relevance in the Nigerian context; therefore, none can be dismissed.

Lack of awareness of DOW (Mean = 3.64) emerged as the single most critical barrier. Respondents overwhelmingly agreed that stakeholders, including designers, clients, and contractors, do not understand what DOW entails, its benefits, or how to implement it. This aligns with Olanrewaju and Ogunmakinde (2020), who found that only 18% of Nigerian architects could define material efficiency.

Lack of experience and skills in implementing DOW (Mean = 3.57) is the second most significant factor, reflecting a capacity gap. Even when professionals are aware of DOW, they often lack hands-on training, particularly in digital tools such as BIM, modular coordination, or waste simulation software, as noted by Mohammed *et al*. (2022).

The lack of DOW tools, such as ICT/BIM (Mean = 3.55), came third, highlighting a technological deficit. Without access to or training in enabling technologies, even willing professionals cannot operationalise DOW. Wong *et al*. (2021) confirm that BIM reduces rework-related waste by 31%, yet it remains underutilised in Nigeria.

Conversely, barriers related to client demand and contractual obligations were ranked the lowest. "Contract does not specify reducing waste during the design phase" was ranked last (Mean = 3.17), with "Project constraints" (Mean = 3.23) and "Lack of client interest" (Mean = 3.26) also ranking near the bottom. While still relevant, these scored lowest, indicating that professionals believe they are more fixable through policy or contractual reform than through addressing deep-seated knowledge/skill gaps. For instance, if clients were educated (Barrier number 1), their interest might increase. Similarly, contracts can be amended, but you cannot suddenly mandate skills. Notably, contractual omission ranked last, suggesting practitioners see this as an institutional lever rather than a cultural/technical barrier.

Discussions

The study identified and ranked the critical barriers to implementing DOW in the Nigerian construction industry. The findings reveal a clear hierarchy of challenges, with deficiencies in awareness, skills, and technology emerging as the most pressing issues. This aligns with findings from other developing contexts where new sustainable practices often face initial hurdles related to knowledge dissemination and capacity building (Esa *et al*., 2017).

The top-ranking barrier, lack of awareness of DOW, suggests that the concept itself is not yet mainstream within the Nigerian construction ecosystem. While academic circles may discuss DOW, it has likely not permeated into daily professional practice. This is a foundational barrier; without awareness, professionals cannot be expected to seek out the necessary skills or tools. The high proportion of early-career respondents (51.2% with less than 5 years of experience) may indicate that DOW principles are not yet sufficiently integrated into university curricula or early professional training programmes. Therefore, capacity-building at academic and CPD levels is imperative. Similarly, the strong representation of quantity surveyors underscores the need to embed DOW principles into cost planning and procurement frameworks.

The second and third-ranked barriers, lack of experience and skills, and Lack of DOW tools, are directly linked to the first. Designing Out Waste (DOW) is not merely a theoretical concept; it requires practical skills in areas like modular design, material selection for deconstruction, and the use of software like BIM for waste analytics (Akinade *et al*., 2018). The perceived lack of these skills and the technological tools to support them creates a significant practical impediment. This highlights a dual need for upskilling the existing workforce and investing in the technological infrastructure necessary for modern DOW practices.

Interestingly, factors often cited as major barriers in developed countries, such as lack of client interest (ranked 14th) and Project constraints (time/cost) (ranked 15th), were perceived as less critical by the Nigerian professionals surveyed. This could be interpreted in two ways. It may be that projects have not even reached the stage where client interest or contracts become the primary bottleneck because the fundamental knowledge to propose and execute DOW is absent. Alternatively, it might suggest that Nigerian professionals believe that if they possessed the requisite skills and awareness, they could effectively make the business case for DOW to clients, even within existing constraints. This contrasts with studies like Osmani *et al*. (2008b), where client-side and commercial pressures were more prominent barriers. The relatively low ranking of Contract, which does not specify reducing waste (16th), further reinforces this point. It suggests that professionals view the problem as one of capability and initiative within the industry, rather than a lack of external, contractual drivers. This finding places a significant onus on professional bodies, educators, and industry leaders to champion DOW from the ground up.

CONCLUSION

This study provides empirical evidence on the barriers to implementing Designing Out Waste (DOW) in the Nigerian construction industry. It concludes that the primary impediments are not external pressures, such as client demand or contractual requirements, but rather internal deficiencies within the professional landscape. A fundamental lack of awareness of DOW principles, a consequent deficit in the necessary skills and experience, and inadequate access to modern technological tools collectively form the most significant roadblock to adopting waste-preventive design practices in Nigeria. Overcoming these foundational challenges is a prerequisite for advancing sustainable construction and integrating circular economy principles into the Nigerian built environment.

RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

a) Professional bodies should: (1) launch targeted awareness campaigns, workshops, and Continuing Professional Development (CPD) programmes focusing on DOW principles and benefits; and (2) develop practical DOW guidelines and best-practice case studies tailored to the Nigerian context, taking into account local materials, construction methods, and regulatory frameworks, to bridge the gap between theory and practice.
b) Institutions should integrate DOW and sustainable design modules into the core curricula for the built environment courses.
c) The industry, in collaboration with government and academia, should invest in training programmes for DOW-related skills, particularly in the use of BIM and other digital tools for waste minimisation.

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